

ECOLOGICAL INVESTIGATIONS ON THE INSECT FAUNA IN ROCK-POOLS IN BLEKINGE, SWEDEN

by Finn Berggren



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Avhandling för doktorsexamen

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Ph.D.

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CORRIGENDA. (ECOLOGICAL INVESTIGATIONS ON THE INSECT FAUNA IN ROCK-POOLS
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- p. 2 line 15: "Chapter III. Ecology on insects" should be Ecology of insects.
- p. 4 line 5: "favorable" should be favourable.
- p. 9 line 10: "I have studies es rock-pools of the 3 types" should be
I have studieded rock-pools of the types.
- p. 16 line 31: (Sturtevant, Wheeler 1953). should be (Sturtevant and Wheeler,
1953.)
- p. 24 line 19: "Sutton, 1951-52" should be Sutton, 1951.
- p. 43 line 13: "compectition" should be competition.
- p. 44 in the table: "S. nigronineata" should be S. nigrolineata.
- p. 50 line 8: "June 13th and 14th" should be May 13th and 14th.
- p. 52 line 17: "registred" should be registered.
- p. 64 line 1: "Than" should be than.
- p. 70 line 31: "POPHAM, E.J. and LANSBURY, I. 1961" should be 1960.
- table 10: "Corethra" should be Chaoborus.
- table 22: "Agubus bipustulatus" should be Agabus bipustulatus.
- table 44: "Hydroporus praecox" should be Hydrophorus praecox.

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Abstract.

The present investigation deals with the insect fauna associated with rock-pools on islands off the Baltic coast of southeastern Sweden (Karlshamns "Skärgård", Prov. Blekinge).

The rock-pools were arbitrarily divided into three groups, viz. (1) those situated closest to the shoreline and highly influenced by sea water; (2) intermediary; and (3) pools which are so far from the sea that they are uninfluenced by it except under exceptional circumstances. 24 rock-pools situated on five islands were studied for a period of three years.

Field observations.

The factors which can be expected to have the greatest significance for the distribution of the species studied are the following:

Salinity. The variations in salinity in the various rock-pools are shown in Appendix I. The differences existing between the three types of rock-pools must be considered as the most influential factor bearing upon the distribution of certain of the species.

Temperature. Variations in temperature were large correlated with air temperature, degree of insolation and the volume and turbidity of the body of water in question (fig. 7).

Acidity. Diurnal variation occurred in individual rock-pools. Variations in pH between the three types of rock-pools were, however, in general greater. The following extreme pH values were recorded. Type 1, 8.5 - 9.5; Type 2, 6.7 - 8.5; Type 3, 4.7 - 7.3.

Oxygen concentration. Wide variations in O_2 -concentration occurred from one day to the next, largely depending upon the degree of insolation via its effect on photosynthesis (fig. 8). However, the greatest differences were found between various parts of the day (fig. 9).

A list containing 56 species is presented; this also shows the average abundance of each species in the pools. Species of particular interest are treated more fully. Concerning the dimorphic species Gerris odontogaster Zett. it was found that the brachypterous form can develop from a macropterous population and that this form possesses much greater powers of dispersal than the brachypterous form. The phenology of G. odontogaster is similar to that of G. asper Fieb. in that in both species the brachypterous forms develop first and the macropterous ones later (see tab. 14 - 15). Callicorixa producta Reut., in common with several other species, shows a dispersal pattern away from rock-pools of type 3 to those of type 2 and 1. This is true despite that fact that this

species is often absent from type 1 pools because of their high salinity. Sea water in this area has a salinity of 7 ‰ which is in excess of what adults of this species are able to tolerate (see experimental results, Chapt. IV). When C. producta and Agabus bipustulatus L. were allowed to colonize a new environment which was favorable to both species, it was found that C. producta was the more rapid colonizer. When Coelambus parallelogrammus Ahr. was presented with a choice of two rock-pools with maximum salinities of 0.7 ‰ and 10 ‰, respectively, a strong preference was shown for the higher salinity, thus indicating the halophilous nature of this species.

Experimental work

Tolerance of Callicorixa producta to NaCl. Adults of C. producta placed in undiluted sea water were found to die within one week. In order that the animals should survive, dilution e.g. in the form of heavy rainfall must occur within three days.

Preference for NaCl. For this work an apparatus with 8 alternative chambers was employed. It was found that C. producta clearly preferred salinities between 1 and 4 ‰. In similar circumstances A. bipustulatus showed a clear preference for salinities between 0.2 and 2 ‰ and therefore does not show any halophilous tendencies. On the other hand C. parallelogrammus showed a preference for salinities ranging between 5 and 8 ‰, which confirms field observations that this species is clearly halophilous.

Influence of temperature on flight. Experimental animals were placed in water which was gradually warmed up. C. producta started to take to wing at 31°C, A. bipustulatus at 28°C. C. parallelogrammus, on the other hand, made no attempts to take off. A lethal temperature of 42°C was established for this species. Since the highest temperature recorded in the field was 24.5°C, it can only very rarely occur that flight is initiated in this way.

Influence of water-depth on flight. C. producta took to wing when the water depth was reduced to 3 cm, Notonecta glauca L. at 4 cm.

Dispersal mechanism of Corixids

Some corixids are found among the first colonizers of newly formed water bodies such as swimming pools, etc. The present investigation included a study of the colonization of an artificial rock-pool. (Chapt. V 1). The number of animals captured was largest at h 08.00, lowest at h 14.00. The number taken at h 20.00 was somewhat less than at h 08.00. Apparently

colonization was greatest at dawn and in the late evening. During the night a light reflecting surface is necessary in order to attract the insects. Increased RH positively effects dispersal activity. Rain has a depressant effect which may be explicable by the fact that these species shows a negative phototaxis when their wings are wet.

In order to investigate the influence of the substrate colour on corixid immigration, an experiment was made using a white plastic basin. In this basin, immigration was only 32% of that in the dark artificial pool. When corixids alight onto water with a background colour with which they do not harmonize, they usually remigrate during light periods when the contrasts are most obvious.

Experiments with UV-light and light traps, show that C. producta actual does undertake spontaneous flights during night, especially in the late evenings. On a calm, overcast, relatively warm night with a high RH, 238 corixid individuals were taken, whereas on another occasion with strong wind, low RH and a temperature on average some 2.5°C lower, the corresponding catch was 13.

C. producta occurs in the investigation area in two forms: the normal form and the flightless form. The last-mentioned also has a paler pigmentation than normal animals. This especially applies to the mesonotum. The indirect flight muscles are highly reduced in the flightless form.

In experiments an increase of temperature released migration tendencies in both forms. Even the flightless form performed short flights. The flightless type can be modified to develop into animals of the normal form when when exposed to increased temperature.

In Callicorixa producta a small population hibernates which in the spring gives rise to the first summer generation. In the following second summer generation the females do not reach sexual maturity untill next spring. C. producta shows strong active dispersal especially during the spring. Several authors have assumed that the releasing factor is rise in temperature. Mass migrations observed in this investigation, however, have not been preceded by any increase of temperature. The opinion that the migration of Corixidae only occurs during the day in periods of sunshine is not correct. My observations indicate that strong spread may occur at night during favourable conditions. Migration before hibernation, observed by several writers has not been observed by me.

Introduction

As a young man I had ample opportunitites to study the rock-pool fauna of the north archipelago of lake Vänern. Since during a number of years I

have lived during the summer in the archipelago of Karlshamn, and my old interest in the rock-pool fauna was revived.

In order to find out what species really occurred there, and also to investigate their distribution and ecology, I started in the spring of 1964 a more accurate investigation of the rock-pool fauna in the archipelago of Karlshamn, the result of which is accounted for in the present paper. I have tried to compare the results of a partly similar examination made by Håkan Lindberg (1944) in the Finnish archipelago.

My investigations, started on a broad basis, has in recent years more and more specialized in examinations and experiments on how certain ecologically important factors influence the distribution and dispersal of some interesting species, particularly of Callicorixa producta Reut., in the area.

Chapter I. Description of the study area.

A. The geographical position and geological structure of the study area.

The study area is made up of clearly defined archipelago within the island-studded coastline of Blekinge, situated approx. 5 Km East of Karlshamn, its longest distance North to South approx. 5.5 Km and its longest distance East to West being also approx. 5.5 Km (see map, fig. 1). The archipelago, which is generally known as Karlshamn's archipelago, is geologically a homogeneous area of primary rock, in which rock-pools of various types are formed dependant upon whether they were formed (during the ice-age) in the dismembered leeside of the ice, which in this case lies on the South and West beaches, or in the soft, sculptured contact zone, situated on the islands' Northern and Eastern sides.

B. Rock-pools.

1. General characteristics.

By the term rock-pools is meant fissures and other depressions in the bedrock structure which are permanently filled by water supplies such as abnormally high tide, spray of waves, spindrift from storms and from surface drainage water and rainfall.

The above characteristics have been the basis of a division into 3 main types of the studied rock-pools.

Type 1. Rock-pools which, at the highest water level, can, but do not necessarily have to, come into direct contact with the sea. They all lie in the "spray-water" zone and they receive spray-water from the sea even at a fairly moderate swell. Rock-pools of this type are situated on the Western, Southern or Eastern sides of the islands, since these parts are well-protected from Northerly winds. The surroundings of these rock-pools are almost devoid of vegetation with the exception of rare occurrences of the salt-lichen Verrucaria maura. The flow of water is lively around these rock-pools and only a thin layer of detritus is formed on the bottom protected within the rock fissures where the wave movements of the water are ineffective. Enteromorpha intestinalis is the commonest plant. Rock-pools of this type correspond to Lindberg's (1944) "Spritzwasserlachen". The salinity of the water varies between 3.9 - 14.3 per mille.

Type 2. Rock-pools of this type lie above the high-water mark of the sea, but at wind speeds in excess of 15 m/sec. sea water can splash into them. On the Northern side of the islands, and in sheltered bays where, because of reasons previously mentioned, heavy swell can almost never be formed,

rock-pools of type 2 can lie only a few decimeters above the sea's high water mark, while on beaches which are exposed to wind, rock-pools of type 2 lie at a normal level of about 1 - 2 meters above sea-level. The production of organic material is, in these cases, greater than that of rock-pools of type 1. The sea never has the opportunity to rinse out these rock-pools effectively, which is why sedimentation is never broken off. The result is a layer of detritus, which in general covers the whole of the bottom of the rock-pool. The surrounding rock-vegetation is sparse, and dominated by lichens, which can, however, show richer development than around rock-pools belonging to type 1. Salinity 0.2 - 9.7 per mille.

Type 3. Characteristic of this type is that they are situated in such an area that only in winds of an extraordinarily high speed can they receive sea water and then only in the form of spray. The albeit low, nonetheless fully measuable ^{r/}Cl-concentration in these rock-pools shows that such is actually the case. The pools are often situated on primary rock plateau and not on sloping terrain, as is the case with types 1 and 2 (see fig. 2). Because of this, the amount of drainage water, which flows into type 3 as a result of rainfall, is not extensive, which is why this type depends heavily upon direct rainfall for its water supply. Pools of type 3 are, in general, larger and deeper than other types because rock-pools which receive water mainly in the form of direct rainfall must have a large water volume in order to exist even during a long period of rapid evaporation. As a result of its size and its reasonably sheltered position from the sea, type 3 has certain special characteristics, viz. the salinity is low, varying between 0.3 - 4.0 per mille, the vegetation both in and around the pool is often more luxuriant and varied compared with the vegetation of types 1 and 2. It follows therefore, that sedimentation of organic material is greater. The bottom of such a pool can be covered by several centimeters of a detritus layer. The transparency is often poor, which is why the development of assimilating algae types is small. Humic acids and a low CO₂ absorption give the water a slightly acid reaction (pH 4.7 - 7.3) while the pH level in types 1 and 2 lies mostly over 7. Certain transitions are included in category 3 from completely vegetationless pools to others which are like miniature marshes. Where any exact category division is difficult to make, I havenot followed Lindberg (1944). based upon Levander (1900) in detail. In group 3 exist rock-pools of the following types according to Lindberg (1. c.):

1. Regenwassertümpel mit glatten Wänden (Rain water pools with smooth walls)
2. Regenwassertümpel mit Vegetationsbedeckten Wänden (Rain water pools

with vegetated walls)

3. Regenwassertümpel mit Torf und Moos (Rain water pools with peat moss)
4. Moostümpel (Moss pools)

2. Examined rock-pools.

Five islands have been marked and named on the map (fig. 1) and on each of these islands one area has been marked in black. Within these black-marked areas lie the rock-pools which have been the subject of examination. I attempted to find as comprehensive an examination area as possible. Thus, within the black-marked zones on each of the islands Sjöö, Tärnö, Harö, Bockö and Mjöö I have studied rock-pools of the 3 types which are described above.

In order to ascertain whether the insects fauna varies according to the distance from the mainland, I wished to create an examination area which runs from North to South. This resulted in the choice of a line Mjöö - Bockö - Harö - Tärnö. In the present examination account has been taken of insects of 3 main categories.

1. Insects, which both as larvae and adults live in the rock-pool.
2. Insects which spend their life only as larvae in the rock-pool.
3. Insects which belong to the coenosis around rock-pools of different types but do not exist in the rock-pool either as larvae or adults.

Designation of the examined rock-pools is as follows:

The name of the island, followed by the rock-pool type (1, 2 or 3).

If more than one rock-pool of the same type has been examined on one island, these are marked in alphabetical order.

The rock-pools are described individually in Appendix I. The observed insects are shown in table form, in Appendix II. There is a photograph enclosed of most of the rock-pools (figs. 26 - 43).

Chapter II.

A. Systematic survey of the insect fauna of the investigated rock-pools and ecological distribution of the species.

List of species (next page).

Directions for the table of the ecological distribution of species in different types of rock-pools.

The diagram includes, in systematical order, all the species found. In the table head habitat and type of rock-pool are presented in the following order:

All rock-pools of type 3 at Sjöö, Tärnö, Bockö, Harö.

Systematic survey of the insect fauna (contin.)

Rock-pool type	3												2												1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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Systematic survey of the insect fauna (contin.)

Rock-pool type	3								2					1				
	Sjö				Tärn		Bock	Harö	Sjö		Tärn	Bock	Harö	Sjö		Tärn	Bock	Harö
	A	B	C	D	A	B			A	B	A	B		A	B	A	B	
(Diptera (contin.))																		
Heterochila buccata Fall.	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	1
Coelopa frigida Fabr.	-	-	-	-	-	-	-	-	1									
Coelopa pilipes Hal.	-	-	-	-	-	-	-	-	1									
Collinellula lutosa Stenh.	-	-	-	-	-	-	-	1										
Cetema elongata Meig.	-	-	-	-	-	-	-	1										
Total: 56 species	9	8	7	7	8	3	10	17	19	16	3	4	5	7	13	6	3	4
Type 3: 39 spec.									Type 2: 33 spec.					Type 1: 13 spec.				

B. Notes on specially treated species.

Hemiptera.

Fam. Gerridae.

Gerris odontogaster Zett.

Ecology: Tychocoenic.¹⁾ Occurs chiefly in waters rich in vegetation, with Phragmites and constitutes the dominating species at the surface in the interior zone of the archipelago of Finland (Lindberg, 1937).

From the rock-pools on Bornholm the species has not been reported.

Flying capacity: The species occurs in macropterous as well as brachypterous form. According to Sahlberg (1920) the brachypterous variety predominates in the northern part of the distribution area and the macropterous one in the southern part. The specimens from Tvärminne are all brachypterous and this is also the case with the main part of the specimens taken at Storbåtskär off Kristinestad (Lindberg, 1944).

1) Eucoenic species: Animals occurring exclusively or primarily within the coenose in question.

Tychocoenic species: Animals regularly occurring within the coenose in question but within other related coenoses as well.

Xenocoenic species: Animals occurring only occasionally within the coenose in question, unable to create a stable population within its biotope.

(In the definitions of the terms, Backlund's (1945) paper is followed).

Distribution in Scandinavia: All the area. In Sweden north to Torne Lapmark (Ossiannilsson, 1947).

General distribution: Great Britain, Western and Central Europe, U.S.S.R. (Stichel, 1955 - 58). The species has mainly a northerly distribution, towards the southern parts of Central Europe it becomes rare (Lindberg, 1944).

Occurrence within the area: With the exception of one single discovery (macropterous form) from Sjöö 3D, on the 10th of May, 1964, G. odonto-gaster has its only habitat on Tärnö where a small population dispersed to all the three types of rock-pools has been observed during the whole period of investigation.

Fam. Notonectidae.

Notonecta glauca Latr.

Ecology: Xenocoenic. Occurs mostly in brooks, rather small rivers and also in temporary pools of water (Richard, 1967). It has been found in the Gulf of Finland (Lindberg, 1927). One record exists from a rock-pool at Randkløve, Bornholm (Johnsen, 1946).

Distribution in Scandinavia: The southern and central parts of Scandinavia. In Sweden north at least to Dalekarlia (Ossiannilsson, 1947).

General distribution: Great Britain, large parts of the mountain areas in Central and Southern Europe (Richard, 1967). It is found in Hohe Tatra 1226 meters above sea level (Lundblad, 1936).

Occurrence within the area: The species was not observed in the investigation area in 1964. In 1965 a few discoveries were made as well of larvae as adults at Sjöö 3C and Harö 2. These rock-pools since then contain permanent populations of the species, from 1966 also at Sjöö 3B.

Fam. Corixidae.

Sigara semistriata Fieb.

Ecology: Xenocoenic. Often occurs in small lakes poor in vegetation (Lundblad, 1936). Infrequent in rock-pools. From Bornholm is recorded one single capture from a rock-pool with the salinity of 7.7 per mille (Johnsen, 1946).

Distribution in Scandinavia: Occurs in Sweden, Norway, Denmark and Finland. In Sweden north to Norrbotten (Ossiannilsson, 1947).

General distribution: Northern and Central Europe, Pyrenées, the region around the Caspian Sea (Richard, 1967).

Occurrence within the area: Only a small number of specimens found at Sjöö 3D, in 1964 and 1965.

Callicorixa praeusta Fieb.

Ecology: Xenocoenic. A northerly species which particularly often is found in small lakes with rich vegetation, often with Amblystegium covering the bottom, but it also occurs in peat pools and ponds (Lundblad, 1936). C. praeusta is seldom found in rock-pools and is not listed by Lindberg (1944) or Johnsen (1946) from investigations of rock-pools in Finland and on Bornholm, respectively.

Distribution in Scandinavia: Occurs in Sweden, Norway, Denmark and Finland. In Sweden north to Torne Lapmark (Ossiannilsson, 1947).

General distribution: In U.S.S.R. around Lake Ladoga and within the taiga zone to the Ural mountains (Richard, 1967). In Great Britain, Central Europe and Balticum (Stichel, 1955 - 58). C. praeusta is a northern palaearctic, possibly holarctic, species also occurring in Kamtshatka (Lundblad, 1936).

Occurrence within the area: Single captures from Sjöö 3B, in 1964 and 1965.

Sigara nigrolineata Fieb.

Ecology: Xenocoenic. Shows a preference for pale clay bottoms with which it agrees in colour. Chiefly occurs in very small pools (Lundblad, 1927). Not common in rock-pools. The species is not listed by Lindberg (1944) or by Johnsen (1946) from investigations from rock-pools in Finland and on Bornholm respectively.

Distribution in Scandinavia: Occurs in Sweden, Norway, Denmark and Finland. In Sweden S. nigrolineata has been found ranging from Scania to Dalekarlia in the north (Ossiannilsson, 1947).

General distribution: Great Britain, the greater part of Western Europe, especially in mountain areas; Caucasus and around the Caspian Sea (Richard, 1967).

Occurrence within the area: Only a few specimens from Sjöö 3D, in 1964 and 1965.

Hesperocorixa sahlbergi Fieb.

Ecology: Xenocoenic. Principally in waters with very rich vegetation (Lundblad, 1927). The species is not recorded by Lindberg (1944) or by Johnsen (1946) from rock-pools in Finland and on Bornholm, respectively.

Distribution in Scandinavia: In Sweden from Scania to Gästrikland. Also in Norway, Denmark and Finland.

General distribution: Eastern part of the Baltic states, Northern Germany (Richard, 1967).

Callicorixa producta Reut.

Ecology: Tychocoenic. Occurs in varying types of water but prefers such

with sparse vegetation and firm bottom of sand and stone (Lindberg, 1944). In Sweden, C. producta occurs in the northern parts particularly in small lakes poor in vegetation but also in rock-pools by the south-eastern coasts (Lundblad, 1936). In the archipelagic zone of Finland, C. producta is one of the most constant species of the rock-pools and occurs mainly in rather young rock-pools without vegetation (Lindberg, 1944).

Distribution in Scandinavia: (Map of distribution, fig. 3) C. producta occurs in Sweden, Norway and Finland. From Denmark there are a few specimens from rock-pools on Bornholm (Johnsen, 1946). C. producta is represented with infrequent occurrence also in Central and Western Sweden (Bohuslän, Halland, Västergötland) but it has its most southerly localities in the outer archipelago of Blekinge (Lindberg, 1944). The distribution of the species in Norway is not very wellknown. The known localities are in the northern part of the country (Lindberg, 1944).

General distribution: (See map, fig. 4). C. producta is known from North-Western U.S.S.R.. Outside Europe two subspecies exist: C. producta norvikensis (Hungerford) in Canada, Alaska and Siberia, and C. producta sackalinensis (Matsumura) reported from Sachalin (Hungerford, 1948).

Occurrence within the area: In the investigation area C. producta has a wider distribution than any other species, possibly with the exception of certain Chironomidae larvae the salinity tolerance of which in general is greater than that of C. producta. The Chironomidae larvae, however, represent several species. C. producta occurs in all the three types of rock-pools with a pronounced peak in type 3.

Coleoptera.

Fam. Dytiscidae.

Agabus bipustulatus L.

Ecology: Tychocoenic. Occurs in pools of varying kind. The species is eurytopic but in rock-pools it is mainly found in the ones rich in vegetation. Limno-euryhaline (Lindberg, 1937).

Distribution in Scandinavia: Sweden, Norway, Denmark and Finland. In Sweden north to Torne Lapmark (Catalogus Col. 1960).

General distribution: The whole of Europe, Kashmir, the Near East (Lindberg, 1944).

Occurrence within the area: The occurrences of Agabus bipustulatus (adults) are distributed in such a way as to show clearly the eurytopic nature of the species. On the other hand observations of larvae exist only from the in many respect homogenous biotope which the type 3.

rock-pools constitute. The main habitats for adults of A. bipustulatus is Harö 3 where through the examination period a permanent though numerically low population has been found. This rock-pool, and also Harö 2 in the close vicinity, of all the pools examined have the best developed vegetation, for which reason the presence of the species is not surprising.

Coelambus parallelogrammus Ahr.

Ecology: Tychocoenic. Occurs chiefly in brackish water (Lindberg, 1944).

C. parallelogrammus must be considered to have halophilous tendencies.

It does not belong to the rock-pool coenosis in other areas. From rock-pools on Bornholm there is a single observation (Johnsen, 1946).

Distribution in Scandinavia: The coasts of southern Sweden. (See map, fig. 5) Akershus fylke in Norway. The coasts of Denmark and Bornholm. (Cat. col. 1960).

General distribution: Throughout Europe, great parts of U.S.S.R., northern Africa (Hoch, 1967).

Occurrence within the area: Several observations of C. parallelogrammus have been made in the habitats on Sjöö and Harö in the rock-pools of type 3 and 2.

Diptera.

Fam. Ephydriidae (det. R. Dahl, Hälsingborg).

Ephydra riparia Fall.

Ecology: Eucoenic. In rock-pools with high salinity. Develops in brackish water, estuaries, salines etc. Larvae and pupae on aquatic plants and accumulations of algae.

Distribution in Scandinavia: The coasts of southern and Central Sweden (Bohuslän, Halland, Scania, Blekinge, Öland, Gotland). The coasts of Northern Norway, Western and Northern Finland (Dahl, 1959).

General distribution: The species is known from marine coasts throughout Europe (Frey, 1931) and from similar biotopes in U.S.A. and Canada (Sturtevant, Wheeler, 1953). Holarctic (Dahl, 1959).

Occurrence within the area: Only small amount of material exists from Sjöö in rock-pools of type 2 and from Tärnö in rock-pools of type 1 and 2.

Ephydra alandica Frey

Ecology: Eucoenic. In rock-pools with high salinity. The ecological distribution correspond with that of Ephydra riparia (see above).

Distribution of Scandinavia: The species was formerly known only from Finland (Frey, 1909), but is now found also on the coasts of Sweden and

Norway (Dahl, 1959). Its geographical distribution in Sweden corresponds on the whole with that of E. riparia. Possibly the species has a wide distribution but has been confused with E. riparia (Dahl, 1959).
Occurrence within the area: E. alandica has stronger populations and wider distribution than E. riparia in the examination area. It occurs in all the islands investigated with the exception of Tärnö and, like E. riparia, it belongs to the coenosis in rock-pools of type 1 and 2.

Chapter III.

Ecology of insects living in rock-pools.

A. General aspects of the rock-pool environments.

Characteristic of the rock-pool environments is their relatively short duration, among other things due to the fact that they are reduced to depending on such unreliable factors as rainfall, high-water level of the sea, spray from the waves, etc. for their support of water. Moreover they are shallow, their surface, and by that also the volume, insignificant, and are in general completely exposed to insolation owing to the frequent absence of high screening vegetation in close vicinity to them.

In small unstatic pools of water like rock-pools (on the other hand) ecologically very important factors change very rapidly and often with steep gradients. Such factors which can be supposed to influence the ecological distribution of the species among different types of rock-pool coenosis are as follows: salinity, acidity, oxygen saturation, transparency of the water, the character of the colour of the bottom, water volume, and depth conditions. The mutual interplay of abiotic factors react on all the organic production in the biotope in question, which quite naturally is of great importance to the development of the species concerned. Organisms which are eucoenic in the rock-pool coenosis and not temporary guests need not only have a good degree of tolerance towards the extremely high or low values that abiotic factors of above-mentioned nature can show, but should also be able to adapt to the rapid changes of the same.

B. Ecological factors of importance to division of the species.

1. Salinity.

Methods for calculating: the salinity has been determined by titrating with AgNO_3 in accordance with Mohr. The method has been chosen on

account of its being common in this kinds of connections so that the received values can directly be compared to those published in other publications. Also the electrolytic conductivity has, on one occasion, been measured for all the rock-pools in order to obtain a reciprocal comparison of the total ion concentration. This method, which must be considered the most exact, however, gives only sums of comparison, which cannot be translated to for instance per mille. Whatever method used, it gives as result some kind of measurement of the Cl-ion concentration in the test and thus not only the NaCl concentration. As is seen by Appendix I, the salinity of a rock-pool may show varying values. Long spells of drought with large evaporation increases the salt concentration in these small volumes of water while the result is the reverse by continuous rain. Rock-pools of type 1 in special are often influenced by the fact that they receive sea-water through lapping of the waves or by high water.

The difference in salinity which on the whole prevail between the three various types of rock-pools must by reasons previously stated be considered to constitute the most important separate existence-ecological factor to certain species. From type 3, with location protected from the influence of sea, and with low salinity, a charge should take place towards more and more exposed pools of types 2 and 1 with a higher salinity. In type 1 the number of species should be low among other things due to this higher salinity. Here also specialized halobiontic species dominate.

According to their relation to water salinity the species of insects present in the examined area can be divided in the following ecological groups (in accordance with Karl, 1930).

A. Thalasso-halobionts.

Definition: Species that at least in the larval stage are bound to salt water and thus only occur by the sea or in salt water in inland parts.

Diptera Brachycera.

Fam. Ephydridae

Ephydra riparia Fall.

Ephydra alandica Frey.

Fam. Dryomycidae.

Heterochila buccata Fall.

Fam. Coelopidae.

Coelopa frigida Fabr.

Coelopa pilipes Hal.

B. Thalasso-halophilous.

Definition: Species that are not entirely dependant on salt water but

may occur also in limnetic environments. However they show a preference for saline biotopes and are often more abundantly developed in these.

Hemiptera Heteroptera.

Fam. Gerridae.

Gerris thoracicus Schumm.

Coleoptera.

Fam. Dytiscidae.

Coelambus parallelogrammus Ahr.

Diptera Nematocera.

Fam. Chironomidae.

Chironomus annularius De Geer. *Paratanytarsus natvigi* Goetgh.

Chironomus halophilus Kieff. *Cricotopus silvestris* Fabr.

Diptera Brachycera.

Fam. Muscidae.

Coenosia pumila Fall.

Schoenomyza litorella Fall.

Fam. Dolichopodidae.

Hydrophorus praecox Lehm.

Campsicnemus armatus Zett.

Syntormon rufipes Meig.

Campsicnemus scambus Fall.

C. Indifferent species (not listed).

Examples of variation of salinity among the three types of rock-pools dealt with here can be seen in fig. 6. Experiments with the salt factor are treated in chapter IV.

2. Temperature.

The general rule is that the water temperature in rock-pools varies greatly, and that these variations with a certain lag, follow the fluctuations of air temperature during day and night. The reason for the characteristic temperature conditions which prevail in rock-pools is most often the slight depth in relation to the surface. This leads to that the received amount of energy through insolation becomes great per unit of volume. For the same reasons the radiation of warmth becomes considerable during night provided that high relative air humidity does not prevail. In rock-pools of the type characteristic of type 1, that is shallow pools with high transparency, temperature becomes almost the same from the surface layer down to the bottom. If, on the other hand, the transparency of a pool is low, or the surface is covered to a great extent by, e.g. *Lemna minor*, by which the energy of light is not able to penetrate down to the deep layers of the water,

vertical differences of temperature become apparent. Fig. 7. shows the variations of temperature during 24 hours in a low transparency rock-pool on three different levels. The fall of temperature (maximum value) from the surface down to 20 centimeters is 7.3°C , while the corresponding fall of temperature from the depth of 20 centimeters down to 1.5 m is only 2.7°C . The species of for instance Coleoptera and Hemiptera that are part of the rock-pool coenosis are forced to surface regularly for their respiration, which often means an increase of temperature by about 10°C within maybe 10 seconds. This should imply special adaptation of physiological nature which in turn probably will react on the ecological distribution in the rock-pools.

3. Acidity.

Rock-pools type 1.

In this group the organic production is very low, the number of heterotrophic organisms small, because of which pH often is close to the value characteristic of the sea water in the area, that is to say completely alkaline. The group is very homogeneous in respects which influence pH. The value fluctuates on the average between 8.5 - 9.5, with the highest value in the afternoon.

Rock-pools type 2.

Group 2, as compared to 1 and 3, takes an intermediate position concerning among other things the organic production, and often also the number of heterotrophes per unit of volume. However, between the examined pools in group 2, there are differences in these respects. For the whole group pH fluctuates between 6.7 and 8.5. The lowest values have been measured in the pools that are in touch with surrounding rich vegetation, e.g. Harö 2. Also in group 2 pH is at its highest in the afternoon but the differences are not so pronounced as was the case in group 1.

Rock-pools type 3.

Group 3 includes different transitional varieties, from pools with no vegetation and pH above 7 to pools that have surrounding vegetations consisting of marsh meadows etc. In these the pH value is low. Within the group pH values between 4.7 and 7.3 have been measured. The highest values on the average, as within group 2, are in the afternoon, 0.5 units higher than shortly before sunrise, when the minimum values are obtained. The low pH values within group 3 probably, among other things, are due to the humic acids which are brought by the surrounding cover of vegetation. Transparency often is low wherefore CO_2 -absorption of assimilating algae is low. In the often thick layers of detritus there

is a continuous high production of CO_2 mainly from the great number of Chironomidae larvae typical of this environment. On the whole the population density of heterotrophes is on the average at its largest in these waters with a high CO_2 production as the result.

The pH measurements have been performed with an electric pH-meter, marked Seibold. All the pH values are from the depth of 10 centimeters.

4. Oxygen content.

In stagnant waters, of the kind represented by the rock-pools, where there is no continuous through flow, the O_2 percentage is very dependant on the relation between oxygen produced by the assimilating autotrophes, and oxygen lost by the total respiration of the system.

The degree of assimilating is to a certain limit, varying with the different organisms, directly dependant on the amount of light for which reason great fluctuations regarding O_2 saturation may take place from day to day (fig. 8.). The greatest variation of the degree of O_2 saturation, however, is found during the different phases of the day.

In the type of example represented by fig. 9. the O_2 saturation in the surface layer increases from 23 per cent by h. 3 a.m. to 192 per cent by h. 1.30 p.m. when assimilation is maximal. On the depth of 0.5 m there are corresponding changes, but here the O_2 saturation is a great deal lower; variations between 7 and 70 per cent.

All the values have been determined through titration in accordance with Fox.

5. Transparency.

Variations of transparency are caused by the amount of particles in the water. The importance of transparency in ecological connections is very great because of the fact that it influences other factors some of which have been mentioned earlier. By low transparency insolation into the water is prevented and only the surface layer is directly warmed, for which reason great differences of temperature appear in the vertical direction. Assimilation in low transparency water can only take place at the surface which in its turn influences the O_2 percentage, the pH value, the organic production and with that all of the bio-coenosis in the system in question.

6. The colour and structure of the bottom.

The percentage of organic material in detritus matter quite naturally is of the greatest importance to the structure and composition of species of all the zoo-coenosis in such a closed system as that represented by a rock-pool. In this paper special attention is paid to

among other things the biology of Corixidae species, in special to dispersal-ecological problems. Macan (1938) has demonstrated that different species of Corixidae show a preference to bottoms the detritus of which varies as to the amount of organic matter. Some require less amount of debris than other species do to provide for their nutrition. Sutton (1951) has explained that Corixidae to a very great extent feed on detritus. From the above is seen that the organic quantity of the detritus may influence the composition of species in a biotope and be a factor which may stimulate Corixidae species to an active dispersal. Regarding the colour of the bottom layers, Popham (1941) has shown that when Sigara distincta is placed against an aberrant back-ground, it gets restless making attempts at migration. This applies also to other species of the Corixidae. The colour which a young adult of the Corixidae develops during its six first hours, and which afterwards does not change, is influenced by the colour of the background. The development of pigment is performed under control from the nervous system with the eyes serving as receptors. Different species have by their basic colour more or less possibility to adjust their colour to the background. There is a high degree of correlation between these colour limits and the choice of biotope by ovipositing females in many species of the Corixidae (Popham, 1942 - 43).

7. Water amount and conditions of depth.

If the water amount of a rock-pool is lowered which usually happens by spells of drought, both temperature and salinity increase, and the density of the population rises by which among other things conditions of stress may appear in certain species, perhaps "triggering off" migrations. A greatly reduced depth of water at least with Corixa punctata can lead to a rapid migration (Macan, 1938).

C. Species of a special interest.

Hemiptera.

Gerris odontogaster Zett.

As is evident from Appendix II and the diagram of the ecological distribution of the species (Chapter II A) a population of G. odontogaster has been present on Tärnö during the whole period of examination. This is the outermost island. From the other islands there is only a single discovery (macropterous form) from Sjöö 3D on the 10th of May, 1964. At Tärnö the species was observed in 3A (table 13) for the first time on the 22nd of June, 1964. The number of specimens was low, and all

were macropterous. It is evident from the description that this rock-pool though it is the only permanently inhabited by the species, neither with regard to the geographical position within the area, nor concerning the vegetation, is what one would expect after having read the information given by Lindberg on the normal choice of biotope by G. odontogaster. Because of this it was presumed that the occurrence the 22nd June, 1964, was to be considered temporary, as all the specimens were macropterous, and it has been observed that this form when swarming flies over great range (Lindberg, 1944).

Contrary to the expectation the population of G. odontogaster at Tärnö 3A increased, however, in number so that in early August the species was common there and by that time also brachypterous specimens and larvae occurred. From August 2nd a few specimens were observed also at Tärnö 2A (table 31). All the specimens were macropterous. No larvae were recorded. On the 19th of August G. odontogaster occurred sparsely also at Tärnö 2B (table 34), 1A (table 58) and 1B (table 61). All the specimens in this rock-pools were macropterous and no larvae were recorded.

In 1965 and 1966 the distribution of G. odontogaster on Tärnö was more or less similar to the situation of 1964, with the exception that the brachypterous form appeared earlier in 3A than the macropterous form. The population has been stabilized in 3A, and as the species is easily detected due to its way of living, it can be established with certainty that it does not occur permanently in other rock-pools of the area. One may presume that G. odontogaster regularly spreads from Tärnö 3A to the more peripherally situated rock-pools 2B, 1A and 1B. This seems to have been repeated all the three years of examination. Only macropterous specimens, with good flying capacity, spread in this way from one rock-pool to another in the late summer after the larval development is finished. In the rock-pools 2B, 1A and 1B food for the Gerridae is seemingly missing but a closer study showed that here they fed on Collembola.

The above observations concerning G. odontogaster show that the species has a great spreading tendency. Also among other Gerridae has it been shown that within wing-dimorphic species a rather great proportion of the macropterous form has a pronounced capacity of active spreading into various kinds of biotopes while the brachypterous varieties are predominant in more stable habitats (Brinkhurst, 1959).

It seems as if G. odontogaster hibernates at least in its brachypterous form in the examination area because the brachypterous form was found much earlier than the macropterous one in 1965 and 1966. Ekblom (1927-

1928) has made the same observations on Gerris asper.

Notonecta glauca L.

As is clear from tables 8, 44 and 6 the species was observed for the first time in 1965 at Sjöö 3C and Harö 2, and in 1966 at Sjöö 3B. It seems as if the species is spreading and taking in possession more and more biotopes suitable to it, for which reason the ecological distribution of the species in the area cannot be established at this stage. As N. glauca was considered an interesting component of the fauna with regard to its predatory activity, which eventually could influence the composition of species in a rock-pool where it was present, a study on this was made at Sjöö in the years 1964 to 1967, for which is accounted in fig. 10. The habitat was a rock-pool of type 3, which is not treated in this paper. From the top diagram (fig. 10) it is clear that Callicorixa producta increased in number a great deal in 1966. From the bottom diagram is seen that the production of phyto-plankton and Daphnia magna also increased strongly during this warm, sunny summer. Investigations have shown that the Corixidae to a great extent feed on plastids from cells of algae, e.g, Spirogyra, and on Daphnia species (Hungerford, 1919; Sutton, 1951-52) wherefore a possible reason for the increase of C. producta is increased amount of food supply. In 1967, the production of food suitable for C. producta (fig. 10) was just about as big as in 1966 but the species decreased very much in July. At the same time was observed that Notonecta glauca increased very much in 1967, which must be presumed to be the reason for the decrease of C. producta. It was observed that, at least in the biotope in question, C. producta constitutes the staple food of Notonecta glauca. A similar interaction between the two species could be observed at Harö 2, in 1966 (table 45).

Callicorixa producta Reut.

C. producta has a wide distribution in all the examination area, with an obvious preference for rock-pools of type 3. My working hypothesis was, that from rock-pools of type 3 with a position protected from the influence of the sea, a dispersal of the species took place towards more exposed pools of type 2 and 1. In type 1 the presence of the species is temporary and the number of specimens is low due to the higher degree of salinity and also to the fact that pools belonging to this category most often are small and shallow. The ecological factors of importance are therefore unstable.

That the species to such great extent is entirely missing in type 1 pools, through experiments later to be described in this paper, has

also proved to be due to its rather low salinity tolerance. It has been established that C. producta in the fifth and last larval stage can stand a salinity of 6 per mille. By an experiment, however, at 8 per mille all the specimens died within 4.5 days, and at between 16 and 20 per mille they died after three days. At the moulting between L5 and imago the tolerance towards salinity is particularly low (Lindberg, 1944).

Colcoptera.

Agabus bipustulatus L.

The species was to be found repeatedly at Harö 3, in 1964. The same year a few specimens of the species were found at Harö 2 close by, on the 15th of July. According to what has appeared from experimental investigations on the salinity preference of the species, (Chapter IV A), the average salinity value is probably too high at Harö 2 for A. bipustulatus to be able to establish a constant population. After the 15th of July, 1964, sea-water broke into Harö 2 in consequence of extremely high water-level, causing the salinity rapidly to approach 7 per mille. After this A. bipustulatus was not refound at Harö 2 during 1964.¹⁾

As seen from table 24, Harö 3 contained populations of A. bipustulatus and C. producta during 1966. The two species were missing on the 27th of July when the pool was almost drained. When it had been refilled C. producta rapidly reappeared, but A. bipustulatus was not observed any more.

Probably the occurrences of as well A. bipustulatus as C. producta at Harö 2, in 1964 and 1966, are due to dispersal from Harö 3. On comparison between the occurrence of C. producta and A. bipustulatus at the above occasions it seems that of the two species C. producta shows the more marked dispersal tendencies.

The other habitat of A. bipustulatus is Sjöö. Here, as at Harö, the species is more likely to be found in pools of type 3 (table 7) but in late summer and autumn, when salinity quite often is low as a result of increased rainfall (see below), the species is also found in type 2 (tables 28-30).

1) Also C. producta, which earlier had shown constancy at Harö 2 disappeared after the above-mentioned flood, but was refound in the pool on the 11th of October when the sea-water had receded, and the salinity had resumed a rather low value.

Salinity at Sjöö 2B was on November, 1st, 1964, 0,5 per mille.

" " " " " " August, 1st, 1965, 0,4 " "

" " " " " " November, 3rd, 1965, 0,4 " "

" " " " " " August, 5th, 1966, 0,6 " "

In a rock-pool adjacent to number 2B, which on account of its topographical position has a rather high salinity (4-6 per mille), A. bipustulatus has been completely missing.

From the here related investigations at Harö and Sjöö it is clear that A. bipustulatus shows tendencies of dispersal but that the species in spite of its attempts is able to establish itself permanently only in rock-pools of type 3.

Coelambus parallelogrammus Ahr.

As is evident from the diagram of the ecological distribution of the species in various types of rock-pools (Chapter II A), C. parallelogrammus shows a marked preference for type 3. The species, has however, somewhat halophilous tendencies, which are confirmed by an experiment concerning the salinity preference of the species (Chapter IV A).

The following field observations from 1964 also indicate a halophilous disposition of C. parallelogrammus: Sjöö 3A a rock-pool of insignificant size, was the main habitat of the species, which occurred there commonly until the 10th of July, after which date the species only was found sporadically as a result of the pool being almost drained. 3B is connected with 3A at high water via a narrow channel. In spite of this passage the species has never been found in 3B, not even during the mentioned desiccation of 3A due to its larger size was completely intact. The reason for failing emigration to 3B may be its too low salinity prevailing during the time in question.

Salinity at Sjöö 3B (extremes) 0,3 - 0,7 per mille.

" " " 3A (") 0,3 - 4,0 " "

The species was discovered at Sjöö 2B on the 19th of April, and found also on the 19th of May, the 15th of August and on the 5th of September (table 28). Between the 20th of June and the 18th of July the species without doubt was not present in the pool, for which reason it is possible that the finds from August result from dispersal from the drained 3A. In 2B, C. parallelogrammus would find a salinity more corresponding to its demands than it would in 3B. 2B: salinity 0,4 - 10,0 per mille.

Diptera.

Ephydra riparia Fall.

E. riparia occurs infrequently in two habitats: Sjöö 2A (tables 25 - 27),

and Tärnö 2B (table 34), 1A (tables 58 - 59) and 1B (tables 61 - 63). E. riparia obviously occurs in rock-pools with high salinity situated close to the sea, which corresponds well to the pronounced halobiontic character of the species. The total number of the collected specimens of the species only amounts to 37 as compared with 194 specimens of Ephydra alandica somewhat unexpectedly, since E. riparia is said to occur abundantly in the majority of the rock-pools examined in Bornholm, from which place E. alandica is not at all mentioned (Johnsen, 1946). Possibly, the two species have not been separated.

Factors, such as temperature, salinity, and wind are in all examined islands of a rather similar kind. E. riparia prefers salinities considerably higher than those generally occurring here. At Sjöö both species occur in the same biocoenose but while more than 100 specimens of E. alandica have been collected, the corresponding number of E. riparia is only 8. Competition between the species could be expected to have some importance, but at Tärnö, where no E. alandica have been observed, E. riparia in spite of this has not established any lasting populations though the ecological factors at Tärnö, with pools most exposed to the sea and winds, should be favourable exactly to E. riparia being a more extreme thalasso-halobiont than E. alandica is said to be (Karl, 1930).

Ephydra alandica Frey.

No ecological differences between E. alandica and E. riparia apart from those mentioned below have been noticed, perhaps partly due to the fact that the material of E. riparia is small. E. alandica has been found in a salinity of 14 per mille which is the maximum value of the area but not of the species. This is also the case with E. riparia. With reference to the lowest salinity values at which adults of both the species have been discovered the figure for E. alandica is 0.4 per mille, and for E. riparia 3.0 per mille.

E. alandica has on some occasions been collected from rock-pools of type 3, while E. riparia never has been found but in types 1 and 2. E. alandica was previously reported to be thalasso-halophilous (Karl, 1930), but has in later literature been classified as thalasso-halobiont. This hesitation as to which group the species belongs to, is understandable considering its large spectrum of salinity choice.

Concerning the phenological distribution of the species it is believed that the adult period is of longer duration in E. riparia than in E. alandica, which is more concentrated to the summer months (Dahl, 1959). This author reports May to August for E. alandica (l.c.).

In the archipelago of Karlshamn, E. alandica has been found during

April to November. Unfortunately no investigations have been possible in other months for which reason it is not known if the species hibernates as adult. However, by the first day of collecting, the 19th of April, the species was numerous at Sjöö 2A, for which reason it is probable that it had been present already earlier. On the last day of collecting the 1st of November, only two specimens were discovered. The above discussion of the salinity demands of Ephydra is based on the assumption that the flies are breeding in the pools where they have been found. No rearing experiments have been made.

Chapter IV. Experimental investigations.

In order to support the results of the field investigations concerning the ecological distribution of some species with regard to their preference for and tolerance towards the factors presented in Chapter III B which possibly might influence the combination of species in the rock-pools and trigger off tendencies of migration, a series of experiments have been made which are related here.

A. Salinity.

1. Tolerance tests with Callicorixa producta.

It has been stated (Chapter III C) and tests have shown that C. producta dies when the salinity is at 8 per mille (Lindberg, 1944). After storms during which the rock-pools may be filled up with pure sea water (salinity 7 per mille) the remaining specimens of C. producta are noticeably influenced by the salinity. In order to find out whether a population of C. producta survives in a rock-pool which thus has had its salinity increased, a partly artificial rock-pool was built at Sjöö and filled with sea water. The water level was marked and the small amount of water evaporated during the test was replaced by rain-water. To make other ecological factors differ as little as possible from those normally prevailing in the rock-pools, a rather big cavity in the mountain was used for the purpose. It had a pass point situated so low as to let flow out all the water which the cavity received. This natural outlet was filled up with as little cement as possible in order to prevent the pH value from rising. pH varied between 6.3 and 6.9 which is well endured by C. producta. Organic matter and Chironomidae larvae were brought there from Sjöö 3B. The surface of the rock-pool was about two meters by one. The depth was 0.3 m. One hundred adults of C. producta were placed in the rock-pool on the 20th of June, 1964. Observations were made each day for six days. The result is clear from

the following table.

Tolerance of Callicorixa producta towards sea water (salinity 7.0 per mille) in a artificial pool (see text).

Date	Observations
June, 21st	The number of specimens reduced by 30 - 40 per cent. The remaining specimens slow.
June, 22nd	No migration tendencies. Grave symptoms of exhaustion.
June, 23rd	No migration tendencies. No more attempts at catching food.
June, 24th	Five dead specimens found. The remaining specimens do not react when touched.
June, 25th	Nine more specimens found dead.
June, 26th	(The rock-pool was carefully examined; sediments were sifted.) 34 specimens were found, among these three specimens showed signs of life, and 31 were dead. (The Chironomidae larvae were in excellent condition.)

From this related test is seen that a population of C. producta after a storm which results in that the water of the rock-pool receives a salinity of 7 per mille, will die within roughly one week unless the salinity is lowered for instance through heavy rain.

The following test shows that if specimens of C. producta, placed in water with a salinity of 7 per mille are to regain their normal functions, the dilution must happen rather soon. One hundred adults of C. producta were placed in sea water (salinity 7.0 per mille). They were supplied with Chironomidae larvae. Each day for the following five days ten specimens were taken up and put in a plastic basin (diameter 1.5 m, depth 0.3 m) which has been filled with water from Sjöö 3B (salinity 0.3 per mille). Into the basin were also brought Chironomidae larvae. The observations are shown in the table on the following page.

Tolerance towards salinity; Callicorixa producta. Exposure in 7.0 per mille salinity water.

Time	General condition among specimens in sea water.	Observations on specimens transferred to basin with 0.3‰ salinity water.
After 1 day.	Weak but obvious tendencies of exhaustion.	All 10 specimens recovered within 10 hours.
After 2 days.	Exhausted.	All 10 specimens recovered within 10 hours.
After 3 days.	Very exhausted. Motions and reactions weak.	All 10 specimens recovered within 24 hours.
After 4 days.	As above. 8 dead specimens found.	4 specimens recovered within 24 hours, 6 died within 3 days.
After 5 days.	As above. 11 dead specimens found.	All 10 specimens died within 24 hours.

The results of the observations in the table show that the probability for a population of C. producta to survive when the rock-pool has been filled with sea water, is small, but that this may happen if the pool after a few days at the latest receives great quantities of rain. Salinity in small rock-pools of type 1, and type 2 as well, may through evaporation be increased to values reaching the critical level when the physiological tolerance of C. producta towards salinity is exceeded. The result is that the population rapidly perishes unless it leaves the biotope in time, and this does not occur to any great extent as is evident from the experiments.

Popham (1946 - 1951) has observed that the case is the same also with other species of the Corixidae, that is to say, if environmental factors are changed unfavourably then the migration tendencies gradually cease and the population perishes.

From the tables (Appendix II) is seen that C. producta often occurs sporadically in rock-pools of type 2. On the occasions when no finds were made, there salinity had reached so high values that the physiological tolerance of the species was transgressed. Part of the population probably had migrated on an early stage the remaining specimens had perished. Later, when salinity was lowered through rainfall, Callicorixa producta soon returned, probably from rock-pools of type 3 representing more stable biotopes than type 1 and 2.

2. Investigations concerning preference.

The investigation apparatus.

In order to establish the salinity preference of certain species experimentally an investigation apparatus working according to the organ principle has been used (see fig. 11). It is made of concrete, circular with a diameter of 40 centimeters, and 10 centimeters high. Its surface was hollowed out making 9 circular depressions 7 centimeters deep and having a diameter of 7 centimeters. One of these basins is located in the middle the remaining 8 are grouped around it. Above this arrangement a plastic globe can be applied. Ventilation is provided by canals covered with straining-cloth. In order to prevent any inconvenient displacements of pH towards basic nature from occurring the concrete has been painted with a dark brownish-green paint as much as possible in accordance with the colour of the species to be examined. As has been mentioned in Chapter III, it has been proved that migration tendencies may be released in the Corixidae if the colour of the background deviates too much from the colour of the body.

Methods of investigation.

The 8 "basins" around the central basin are filled with water, the NaCl content of which varies from for instance 1 to 8 per mille, depending on which species is the subject of the investigation. Ten animals were placed in the central basin after which the plastic globe is put on. After 30 minutes the distribution of the specimens in the eight peripheral basins is recorded. The experiment is repeated with new animals until a material large enough to be statistically useful has been obtained.

Callicorixa producta (fig. 11).

In the experiments 80 per cent of the specimens were distributed rather evenly within the zone of 1 to 4 per mille salinity. This result confirms field examinations from which it has been clear that the species when imago does not show complete tolerance towards a salinity higher than about 5 per mille.

All the animals moved to the water-filled basins by creeping not flying. Only 7 out of the 103 specimens in the test remained in the first basin that they have occupied, irrespective of whether the salinity there was high or low. The majority moved away from unfavourable habitats and finally reached one more suitable for the species. Two basins or three basins (observed in 8 instances) were usually tried and abandoned during the 30 minutes of the test. The final choice of basin apparently followed the principle of trial and

error.

Notonecta glauca (fig. 12).

In the investigation area the species shows preference for rock-pools of type 3 and 2 but has not been found in type 1 rock-pools which are characterized by higher salinity. The result of the preference experiments, in which the animals were rather evenly distributed, does, however, not indicate that N. glauca would have difficulties in adapting itself to the type 1 rock-pool on account of its high salinity. On the other hand, investigations have suggested that the species may be sensitive to the high values of pH which often prevail in these pools (Chapter IV D).

During the test the animals moved by creeping. They were very active, only a few of them remaining in the basin they had first occupied. By the creeping between the basins the animals did not follow the principle of trial and error but occupied any basin regardless of salinity, which is evident from the final distribution.

In order to find out if N. glauca also during a rather long period is able to adapt itself to the highest values of salinity in the investigation area, the arrangement and procedure from the pH tolerance examinations were used. Water was brought in from Sjöö 1B. As food were added Corixidae and Chironomidae larvae. Test material: 20 specimens of Notonecta glauca (adults). Time of observations: three days and nights with observations at 9 a. m. and 6 p.m. The experiment was begun on the first evening at 6 p.m. Salinity: 14.3 per mille, pH 7.6 - 7.9. Temperature: 19.5 - 21.8 °C. Result: No animals made any attempts at leaving the pool during the time of observation. All the specimens were in good condition by the time the experiment expired. For conclusion see experiments with pH, Chapter IV D.

Agabus bipustulatus (fig. 13).

The result of field observations concerning the ecological distribution of A. bipustulatus is described in Chapter III C. They indicate that A. bipustulatus shows tendencies of distribution within different rock-pool habitats but only in such with low values of salinity. The experiments on preference also add to the picture of a species without any halophilous tendencies, with 80 per cent of the specimens restricted to 0.2 - 2.0 per mille salinity.

The following observations shows that the final choice of basin to a great extent was made according to the principle of trial and error. All the animals moved to the waterfilled basins by creeping. Only four specimens out of 104 test animals remained in the basin that they first

had occupied, irrespective of salinity. Specimens that had entered a basin with too high salinity moved away from it finally reaching a more suitable basin. In five instances three basins were tried and abandoned and in one instance four basins.

In order to find out how A. bipustulatus reacts to a longer period of certain salinities, tests similar to those with Notonecta glauca (above) were made.

Test material in each experiment were 20 specimens of A. bipustulatus (adults). Time of observations three days with observations at 9 a.m. and 6 p.m.

I. Salinity: 3.5 per mille, pH 6.1 - 6.7. Temperature: 19.7 - 20.3 °C.
Result: Three specimens had left the pool on the first day by 6 p.m., another three specimens on the second day by 9 a.m. After this there were no numerical changes. The remaining animals were in good condition by the time the experiment was finished.

II. Salinity: 6.7 per mille, pH 7.8 - 8.3. Temperature: 19.6 - 20.3 °C.
Result: 12 specimens had left the pool on the first day by 9 a.m., another three specimens by 6 p.m. on the following day. After this there were no numerical changes. By the time the experiment was finished the remaining five animals were in poor condition, mostly floating on the surface with difficulties in diving.

Coelambus parallelogrammus (fig. 14).

The result from field observations on C. parallelogrammus (Chapter III C) shows that the species has apparent spreading tendencies and a preference for salinities revealing halophilous disposition. The distribution of specimens in the experiments on preference confirms this. Of the material, 63 % were distributed among the 5 - 8 per mille salinity. The distribution is uneven, but as seen in the diagram, there is an evident preference for the 5 - 6 per mille salinity. The following observations show that also this species chose its basin according to the principle of trial and error. All the specimens moved by creeping to the water-filled basins. Six of them remained in the dry central basin. These latter are not accounted for in the distribution data. Only nine out of 106 specimens remained in the basin that they first occupied in spite of the fact that the salinity was often suitable. The species was tested during three successive days in accordance with the principles applied to the species previously mentioned. The conditions were as follows:

Investigation material: 20 specimens in each experiment.

I. Salinity: 1.0 per mille, pH 7.4 - 7.8. Temperature: 19.2 - 19.9 °C.

Result: On the first day by 9 a.m. one specimen had left the pool, another two specimens had left it by 6 p.m. the next day. On the third day three specimens had left the pool by 9 a.m. After this there were no numerical changes. The remaining number of specimens was 14 by the time the experiment was finished, all of them in good condition but more restless than normally.

II. Salinity: 7.7 per mille, pH 5.6 - 6.0. Temperature 19.4 - 19.8°C.

Result: On the first day by 9 a.m. one specimen had left the pool. Otherwise no numerical changes occurred. The remaining number of specimens was 19 by the time the experiment was finished, all of them in good condition.

B. Temperature.

During the periods with high evaporation, high temperature of air and strong insolation, the temperature of rock-pools greatly rises (fig. 7). The increase in temperature applies in particular to pools of type 1 and 2 which, contrary to type 3, often have high transparency and slight water depth, for which reason they are homogeneously warmed from surface to bottom.

The following investigations have been made in order to establish for certain species the possible migration starting effect caused by a successive increase in temperature.

The effect of successive increase of temperature.

Methods of investigations: A beaker of one litre filled with water (18°C.) was placed in a water-bath, warmed by an immersion-heater. 10 specimens were put into the beaker after which the temperature increased with about 1°C per 5 minutes. In order to achieve an even distribution of heat the beaker was slowly stirred. The reactions of the experimental specimens were observed and the number of attempts at flight was registered. The species investigated all lack the ability of taking off from the surface. As attempts at flight are regarded the instances at which a specimen passes the surface film spreading its wings. In these instances the animal was brought back into the beaker for which reason the same individual may make several attempts at flight, all of which are counted.

Experiments on the effect caused by successive increase of temperature.

Callicorixa producta.

20°C	No attempts at flight.			
22°C	"	"	"	"
24°C	"	"	"	"
26°C	"	"	"	"
28°C	"	"	"	"
30°C	"	"	"	"
31°C	1 attempt	"	"	"
32°C	2 attempts	"	"	"
33°C	18	"	"	"
34°C	36	"	"	"
35°C	52	"	"	"
36°C	The animals show tendencies of exhaustion.			
37°C	The animals show strong tendencies of exhaustion.			
38°C	One specimen died.			
39°C	All the specimens died.			

Notonecta glauca.

20°C	No attempts at flight.			
22°C	"	"	"	"
24°C	"	"	"	"
26°C	"	"	"	"
28°C	"	"	"	"
30°C	"	"	"	"
32°C	All specimens close to surface.			
34°C	All specimens close to surface.			
35°C	1 attempt	at flight.		
36°C	1	"	"	"
37°C	3 attempts	"	"	"
38°C	Attempts at flight of all the specimens.			

Experiments on the effect caused by successive increase of temperature.

Agabus bipustulatus.

20°C	No attempts at flight.			
22°C	"	"	"	"
24°C	"	"	"	"
26°C	"	"	"	"
28°C	2	"	"	"
29°C	6	"	"	"
30°C	Attempts at flight of all the specimens.			

Coelambus parallelogrammus.

20°C	No attempts at flight.			
22°C	"	"	"	"
24°C	"	"	"	"
26°C	"	"	"	"
28°C	"	"	"	"
30°C	"	"	"	"
32°C	"	"	"	"
34°C	"	"	"	"
36°C	"	"	"	"
38°C	"	"	"	"
40°C	The animals swim towards bottom.			
41°C	No attempts at flight. The animals remain at bottom.			
42°C	All specimens dead, floating up towards the surface.			

Callicorixa producta.

Popham (1942 - 43) has shown that temperature has an obvious influence on the spreading tendencies of Sigara distincta. Already at the temperature of 20°C attempts at flight started. The maximum was reached by 30°C. At temperatures more than 35°C the animals tend to die. The table above shows that Callicorixa producta on the whole reacts as S. distincta, though rather having a greater tolerance towards high temperatures, which is reflected by the fact that attempts at flight do not start until 31°C. At higher temperatures the flying tendencies cease, the limit of tolerance towards warmth is transgressed and the animals die.

Notonecta glauca.

From the table is seen that the reaction of Notonecta glauca to a

successive increase of temperature are very much weaker than those of Callicorixa producta. The tolerance towards increase in temperature of the species is great. A few attempts at flight were performed between 35 and 37°C. By 38°C all the specimens show flying tendencies.

Agabus bipustulatus.

The reactions of Agabus bipustulatus to an increase of temperature are of the same kind as those of Notonecta glauca, though with a shifting of about 7°C towards a lower value. A few attempts at flight are started by 28 to 29°C, after which all the specimens react with attempts at emigration by 30°C.

Coelambus parallelogrammus.

In the reactions to an increase of temperature this species differs from the other species investigated in so far that no attempts at flight occur. Coelambus parallelogrammus does not even swim to the surface at high temperatures but goes for the bottom, after which they die by 42°C.

From the above is seen that three out of four species investigated clearly react with flying tendencies by high temperatures. As these high temperatures (maximum 24.5°C) have, however, never been measured in the rock-pools investigated, it is not realistic to count on increases of temperature, normal for the area, as resulting in emigration and subsequent spreading.

One of the reasons, however, for the absence of Corixidae from very small and shallow ephemeral pools of water may be the exceptionally high temperatures which occasionally may prevail in them.

C. Depth of water.

During periods of warmth and drought the depth of water and subsequently the volume of rather small rock-pools strongly decrease which results in an increase in density of population unless migration is released. Investigations that have been made on certain species in Great Britain have, however, shown that the species concerned are not sensitive to a high density of population (Macan, 1938).

In order to establish at what depth of water migration would possibly be released in certain species, the following experiments have been made.

Experiments on the effect of reduced depth of water.

Methods of investigation: A beaker of 1 litre, graded to centimetres, was filled with water up to the level of 12 centimetres. Temperature

of the water: 20°C. pH 6.3. Salinity: 1.3 per mille. 10 animals are released into the beaker. Every five minutes the depth of water is reduced, as shown in the table below. Every attempt at flight is registered. Animals making such attempts are returned to the beaker.

Callicorixa producta.

Depth of water 12 cm.				No attempts at flight.				All specimens swim towards the bottom.	
"	"	"	9 cm.	"	"	"	"	"	"
"	"	"	6 cm.	"	"	"	"	"	"
"	"	"	4 cm.	"	"	"	"	"	"
"	"	"	3 cm.	1 attempt	"	"		Specimens more evenly distributed.	
"	"	"	1.5 cm.	4 attempts	"	"		"	"
"	"	"	1 cm.	26	"	"	"	"	"

Notonecta glauca.

Depth of water 12 cm.				No attempts at flight.				Specimens evenly distributed.	
"	"	"	9 cm.	"	"	"	"	"	"
"	"	"	6 cm.	"	"	"	"	"	"
"	"	"	4 cm.	2	"	"	"	All specimens by the surface.	
"	"	"	3 cm.	2	"	"	"	"	"
"	"	"	2 cm.	3	"	"	"	"	"
"	"	"	1.5 cm.	4	"	"	"	"	"
"	"	"	1 cm.	10	"	"	"	"	"

Callicorixa producta.

The experiment shows that Callicorixa producta reacts with attempts at flight when the depth of water goes down to 3 cm. By a further reduced depth of water the attempts increase markedly, 26 being noted by the depth of 1.5 cm.

Notonecta glauca.

The experiment shows that Notonecta glauca begins to react by the depth of 4 cm. By a further reduced depth the flight reactions continue, though without the great increase in number observed in Callicorixa producta.

Agabus bipustulatus and Coelambus parallelogrammus have not been in-

cluded in this investigation as they have proved able to remain in the moist bottom sediment in otherwise dry rock-pools.

A depth small enough to release flying tendencies in the above species, only seldom occurs in the investigated rock-pools. By rainfall, on the other hand, small temporary pools of little depth are formed but are not colonized by the species in question. A contributory cause for this may be that rather immediate emigrations are triggered off. The result of the investigation shows that a single factor changed in a negative way may act as a signal of alarm and cause emigration and spreading. During natural conditions a strongly reduced depth of water in the rock-pools will mean changes also of other factors of great importance in the complex. Such effects caused by evaporation are increase of salinity and temperature, changes of pH, increased density of population, and thus a disturbance in the entire balance of the biotope.

D. Values of pH.

Popham (1941) has made investigations on the reactions and possible migration tendencies of Sigara distincta in environments with different values of pH. Acidity was increased by means of citric acid.

S. distincta did not show any tendencies of migration even at so low a value as pH 3. The negative ion of the citric acid, however, is a foreign substance with an intense taste (at least to man) the influence of which on the animals in test cannot be overlooked. In the present investigation, water from the investigation area has been used, representing all of the pH series which exists there, that is to say pH varying 4.7 to 9.5. The same working methods and the same arrangement as in the experiments on salinity preference were used (Chapter IV A).

Results (figs. 15 - 18).

Callicorixa producta. The test shows that C. producta has a wide tolerance towards varying values of pH and does not show any preference between the extreme values present in the area. The salinity was maximum 3.7 per mille which is well tolerated by the species.

Notonecta glauca. Though the material is little the test shows that N. glauca prefers rather low, and medium high values of pH. The salinity was maximum 4.2 per mille which is well tolerated by the species.

Agabus bipustulatus. The result shows that A. bipustulatus has a wide

tolerance towards the values of pH existing in the area and does not show preference in any way. The salinity was maximum 2.7 per mille which is well tolerated by the species.

Coelambus parallelogrammus. The result shows that C. parallelogrammus has a great tolerance towards the rather high values of pH which often characterize the type of rock-pools which are rather saline. The salinity was maximum 5.5 per mille which is well tolerated by the species.

In order to investigate how the four species discussed above would react during a prolonged stay in water where, respectively, the lowest and the highest pH values of the area are prevailing, the following test has been made:

Into a cavity, made of concrete, was poured water of the kind against which the species was to be tested. The water was taken from pools in the investigation area. Organic matter and Chironomidae larvae were added to a suitable quantity. The surface of this artificial rock-pool was approximately 1 m² and at the deepest 15 cm. The edges were made shallow and rough in order to make it easy for the animals to creep out of it. Over the entire arrangement was stretched a fine-meshed net.

One species at a time was tested for a period of three days with observations at 9 a.m. and 6 p.m., respectively. The material in each test consisted of 20 specimens from each of the species.

Callicorixa producta.

I. pH 4.7 - 4.9. Result: No flight tendencies, nor any tendencies of exhaustion. The animals were in good condition after three days. (In a similar test when pH was reduced to 3.0 by means of tartaric acid the same result was obtained.)

II. pH 9.2 - 9.5. Result: As above.

Notonecta glauca.

I. pH 4.7 - 4.9. Result: No flight tendencies, nor any tendencies of exhaustion. The animals were in good condition after three days. (In a similar test when pH was reduced to 3.0 by means of tartaric acid the same result was obtained.)

II. pH 8.0 - 8.4. Result: As above.

III. pH 9.2 - 9.5. Result: Two specimens had left the pool by 6 p.m. the second day. Three more specimens had left the pool by 9 a.m. the third day, and another three had left it by 6 p.m. the same day. The total number of remaining specimens was 12 by the time the test was

finished. The animals were in good condition all the time.

Agabus bipustulatus.

I. pH 4.7 - 4.9. Result: No flight tendencies, nor any tendencies of exhaustion. The animals were in good condition by the time the test was finished.

II. pH 8.9 - 9.2. Result: As above.

Coelambus parallelogrammus.

I. pH 4.8 - 4.9. Result: One specimen had left the pool by 6 p.m. the second day. Another four specimens had left the pool by 6 p.m. the third day. The total number of remaining specimens was 15 by the time the test was finished. The animals were in good condition throughout the test.

II. pH 9.2 - 9.4. Result: No attempts at flight, nor any tendencies of exhaustion. The animals were in good condition by the end of the test.

Conclusions:

Callicorixa producta.

The field investigations on the ecological distribution of the species (Chapter II A) show that it occurs in all the types of rock-pools, as well in those with high values of pH as in those with low values. Observations by the tests on pH to a great extent strengthen the impression that C. producta is completely adapted to all the pH values existing in the area. These values, consequently, hardly can have any direct influence on the ecological distribution of the species as was the case with the salinity values (Chapter IV A).

Notonecta glauca.

The distribution of the species in the investigation area (Chapter II A) in rock-pools of type 3 and 2, but not in type 1, gives reason to presume the existence of one or more limiting factors in type 1. Characteristic of this type is its lack of organic matter which leads to a low number of species as well as specimens for which reason the absence of N. glauca to a great extent is caused by lack of food. The pH tests, however, show that even if food is available N. glauca after a while shows tendencies of migration when pH is between 9.2 and 9.5 but not when the value is 8.0 to 8.4. pH values as high as, or higher than, 9.0 only occur in rock-pools of type 1. Their high salinity which may kill Callicorixa producta, however, does not seem to be able to restrict the distribution of N. glauca as the species

in tests has proved resistant to the highest values of salinity in the area (Chapter IV A).

Agabus bipustulatus.

The distribution of the species is limited to rock-pools of type 2 and 3 (Chapter II A). In spite of attempts of dispersal it does not seem able to adapt to biotopes with a salinity high for the area (Chapter III C). In investigations on preference for salinity it is clearly seen that the species shows preference for low values (Chapter IV A). Also the pH value would be a possible factor to take into account. From the tests with pH, however, it is evident that the acidity is of minor importance as the species in both of the tests was completely adapted to all the existing values.

Coelambus parallelogrammus.

The species has proved to have halophilous tendencies (Chapter III C and IV A). In the pH tests is shown that it is able to endure the high values of pH which often prevail in the more saline rock-pools of type 1 and 2, for which reason the attempts at colonizing these types of biotopes, as observed in the field, are probably not restricted by the pH value. The low frequency in pH 4.8 to 5.4 of the preference test is not significant in the investigation area where C. parallelogrammus several times has been found in pools of type 3 which among other things are characterized by low values of pH.

Chapter V.

Dispersal biology of the Corixidae.

An interesting question is how a recently formed pool is invaded by the Corixidae.

It has been established (Popham, 1942 - 43) that in new pools for instance swimming pools, certain species of Corixidae are among the first insects to arrive and colonize, which fact shows an active spreading tendency in the species concerned.

Sometimes, rock-pools of rather similar kind and only a few meters apart, show great differences with regard to the composition of species and size of population within the individual species. There are observations of this kind from Great Britain (Popham, 1946 - 51), and from the present investigation, Sjöö 3C and 3D can be mentioned as good examples.

In Sjöö 3D (table 10) a very dense population of Callicorixa producta was present in 1964, larvae as well as adults. During the same period

the species occurred also in 3C (table 7) but much less abundantly and no larvae were found. Conditions were the same in 1965 (tables 8 and 11) but this year 3C was invaded by a predator, Notonecta glauca, that to a very great extent uses Callicorixa producta as food. for which reason 3C and 3D no longer could be considered comparable with respect to factors regulating the respective populations of Callicorixa producta. The abundant occurrence of larvae indicated good conditions for the species in 3D as the effect of the biotope on fertility, oviposition, and mortality among the larvae is most important, When Corixidae colonize new biotopes it is probably done through their spreading evenly over the different bodies of water within reach of their spreading capacity, but they are reduced in number in some of them through predation or competition of other species, notably in environments to which they are not well adapted. An alternative possibility is re-migration, that is to say, that animals not adapted to a new environment migrate away from it.

By observations made in Great Britain (Popham, 1946 - 51) and from results of experiments made in this investigation, accounted for in chapter IV, it appears that if the salinity is increased above a certain level the migratory tendencies of Corixids gradually disappear. It is possible that the same reaction will occur if the species through spreading at random gets into an environment unfavourable in other respects.

1. Immigration to an artificial rock-pool.

The table on the next side shows the immigration of Corixidae into a new rock-pool during a period of ten days, with three observations made each day. The artificial rock-pool was made according to the principles described in part A, chapter IV. The bottom had a layer of detritus and was therefore dark.

During the course of the test the following values of ecologically important factors prevailed in the rock-pool: salinity 3.1 - 3.6 per mille, pH 6.6 - 7.1, maximum temperature 21.6°C. The surface was about 9 m² and maximum depth 25 cm.

The rock-pool was exposed on the 15th of May at h 20 p.m. The animals were removed after every counting.

Immigration of Corixidae into a new rock-pool. Sjöö, June, 1966.

Date	Species	Specimens arrived			Weather
		h 8	h 14	h 20	
16	<i>C. producta</i>	4	3	6	cloudy, calm
17	"	4	0	0	rain
18	"	5	0	0	very dry, hot
19	"	7	1	0	" " "
20	"	4	4	5	cloudy, cool
21	"	11	3	9	" "
	<i>S. nigroneata</i>	1	0	0	" "
22	<i>C. producta</i>	9	0	2	dry, hot
23	"	6	0	1	" "
24	"	10	6	6	cool, fog
25	"	7	5	6	" "
total:		68	22	35	

Total number: 125 specimens.

Conclusions from the table:

1. Within the area there is an active spreading of Corixidae. Among the species present in the investigation area, Callicorixa producta has an overwhelming numerical dominance and also a greater geographical distribution than other species of Corixidae. Under these circumstances the distribution in the table is what might be expected.
2. The number of caught animals has been highest at h 8 in the morning, lowest at h 14, and than again increased at h 20 in the evening. Obviously the spreading tendency is highest at dawn and dusk, not during the darkest hours of the night, as it takes a light-reflecting surface to make the animals settle (Popham, 1946 - 51) and this is not the case unless there is moon-shine.
3. During warm and dry days, resulting in a low relative humidity, the migration tendencies become small.
4. When the weather conditions are characterized by rain, the spread ceases, which is natural as the species shows negative phototaxis as long as the wings are wet (Popham, 1942 - 43).
5. The relative air humidity, among other factors, seems to be of great importance for the spreading ability of the Corixidae. At low R.H., their activity is reduced. Popham (1946 - 51) reports that at very low R.H. values, Corixidae fall on their backs and sides and become immobilized after about two hours. The time of this reaction seems to be connected with the volume of the body; the bigger it is, the longer

time it takes for the reaction to appear. The dispersal area consequently increases with increasing air humidity, at least to a certain extent. This may contribute in explaining the increased number of arrivals to the pool on the 16th, the 21st, the 24th and the 25th of June, days with high R.H.

2. Effect of the bottom colour.

As has been pointed out (chapter III B) the shade of the bottom colour and the amount of organic matter in the debris have proved to be important factors for the composition of Corixid species in a rock-pool.

In order to find out the effect of the bottom colour on the immigration of Corixidae into a new biotope, the following test was made. Quite close to the artificially formed rock-pool described above was placed a plastic basin without detritus, that is, with white bottom colour. The surface was about 1.8 m^2 , the depth 25 cm. The quality of the water was equal to that of the rock-pool. The result is seen from the following table.

Immigration of Corixidae into a basin with white bottom. Sjöö, June, 1966.

Date	Species	Specimens arrived		
		h 8	h 14	h 20
16	<i>C. producta</i>	1	0	0
17	"	0	0	0
18	"	"	0	0
19	"	0	0	0
20	"	1	0	0
21	"	0	0	0
22	"	0	0	0
23	"	0	0	0
24	"	2	0	2
25	"	2	0	0
total		6	0	2

Total number: 8 specimens.

From the table is evident that the plastic basin recieved only 8 specimens during ten days while the corresponding number for the artificially formed rock-pool was 125. The surface of the plastic basin, however, was only a fifth of that of the rock-pool, for which reason the numbers of comparison are 40 to 125. This means that the immigration to the plastic basin counted per surface unit was only 32 % of that of

the rock-pool. The smaller surface of the plastic basin, however, may have resulted in an inferior power of distance attraction. The distribution in time is similar in both cases. In both experiments most of the specimens were caught at 8 a.m. The white bottom colour, which harmonizes very badly with the colour of the animals has no doubt worked a factor of disturbance against colonization. The contrast is of course most pronounced in the middle of the day and consequently no specimens were observed at h 14.

However, it seems probable that during the night with weak colour contrasts, the Corixidae to a certain extent migrate into environments with a bottom colour that is unfavourable, and then remigrate during the day.

In order to investigate experimentally if this is true a number of specimens of several species of Corixidae were placed in a plastic basin with white bottom. The basin was filled with water from Sjöö 30 in which Corixidae feel well at home. The test was started in the evening when it was dark. The migration away from the basin is seen from the following table.

Emigration of Corixidae from a basin with white bottom colour. July 10th, 1967.

Species	Specimens left						Total ./ emigrants
	h 23	h 2	h 6	h 9	h 12	h 16	
<i>S. semistriata</i>	5	5	5	5	3	2	60
<i>C. praeusta</i>	5	5	5	5	4	4	20
<i>S. nigrolineata</i>	5	5	5	3	2	1	80
<i>H. sahlbergi</i>	5	5	5	4	2	2	60
<i>C. producta</i>	10	10	10	7	4	2	80

The table shows a varying percentage of emigrations for the different species. The number of five specimens tested in four of the species is, however, too small from a statistical point of view, but more specimens were not available. Investigations in Great Britain have shown that *Sigara nigrolineata* is especially willing to migrate (Brown, 1951) which is indicated also by this investigation. The same figure of migration is shown by *Callicorixa producta*, which was not included in the investigations made in Great Britain (Brown, 1.c.). From the table is also evident that during darkness no migrations were released in the species investigated. The largest migration occurred between h 9 and noon, the only period when all the species took part.

3. Flight during day and night.

In order to find out whether Corixidae fly during night, a light-trap with faint UV light was used on the island Sjöö two nights during which observations were made every hour concerning the number of attracted Corixidae. The results of the observations are seen from the tables below and and diagram. (Fig. 19).

Number of Corixidae collected with light-trap. Sjöö. July 1967.

Temp. °C	17.6	17.3	16.9	16.4	16.0	15.7	15.4	15.1
Time	h 22	h 23	h 24	h 1	h 2	h 3	h 4	h 5
<i>C. producta</i>	34	29	61	57	31	19	7	0
<i>H. sahlbergi</i>	0	0	0	0	1	0	0	0

Total number: 238 specimens.

Weather conditions: calm, clouded. High R.H. Date July 14th and 15th.

Number of Corixidae collected with light-trap. Sjöö. July 1967.

Temp. °C	15.3	15.0	14.6	14.2	13.5	12.8	12.3	11.7
Time	h 22	h 23	h 24	h 1	h 2	h 3	h 4	h 5
<i>C. producta</i>	4	6	0	3	0	0	0	0

Total number: 13 specimens.

Weather conditions: Wind velocity until h 1 about 6 meters per second, then rapidly increasing to 14 meters at h 5. Bright, low R.H. Date July 23rd and 24th.

The figures of temperature have been obtained at 1.5 m above the ground.

From the tests with light-trap it is evident that out of a total number of 251 collected Corixids 250 specimens were Callicorixa producta, the dominant species in the investigation area. C. producta flies spontaneously during the night. The collecting lamp cannot have induced the animals to leave the rock-pools because it has been proved that the Corixids remain neutral to light while in water. Only out of the water, when their wings have dried, do they show positive phototaxis (Popham, 1942 - 43).

The top diagram (Fig. 19) illustrates how the number of attracted specimens increases before midnight and then rapidly decreases after h 1.

The reduced number between h 3 and 4 may partly be due to the diminished efficiency of the light-trap with growing daylight, but the tendency after all is quite obvious also between h 1 and h 3 when it was dark. The difference in temperature is slight and may probably be neglected.

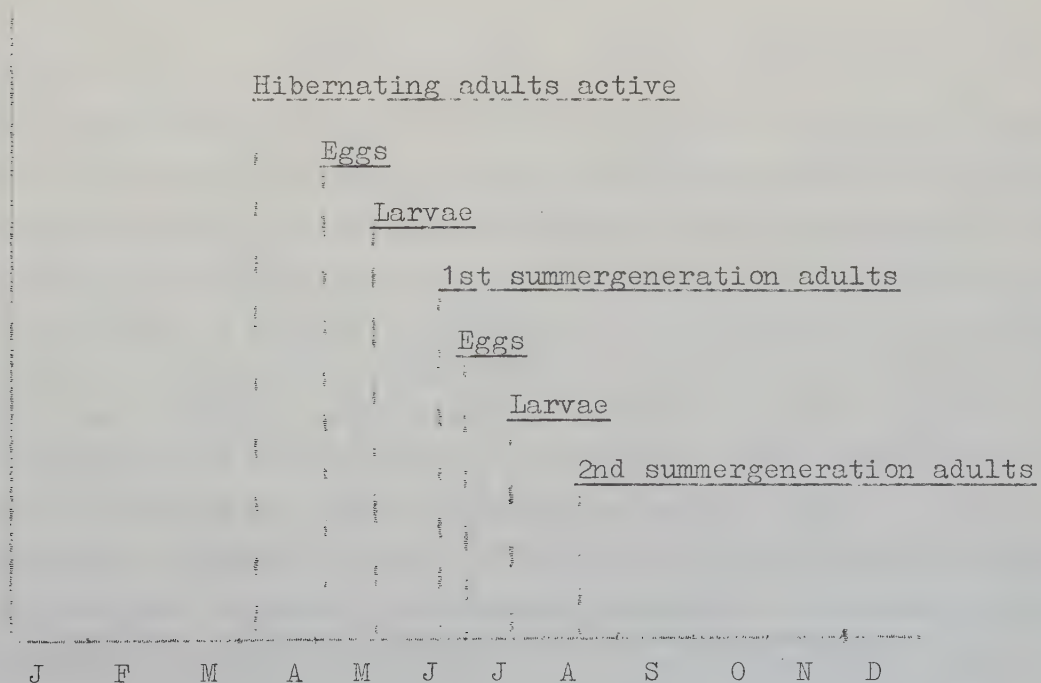
The difference in number of collected specimens between the two nights is pronounced. The first test was made during the night of July 15th, the second of July 24th, and it is not likely that there could have been considerable numerical changes of the Callicorixa producta population in the area as to influence the result. The reason for the difference should be looked for in the weather conditions which were very different in the two nights. At low values of R.H., the flight capacity of the Corixidae is reduced. This fact in its turn reduces the size of the radius of the dispersal area of the population. It is evident from the second table above, July 24th, that under such conditions not a single specimen arrived after h 1. Additional negative factors could possibly be very strong winds and a low air temperature.

4. Flight in the different seasons.

Seasonal occurrence of the two generations of Corixidae with particular regard to Callicorixa producta.

The following life-cycle stages and morphs can be distinguished:

Life-cycle stages
and morphs



Hibernating females are sexually mature, with developed ovaries, in the first or second week of May, males about two weeks earlier when copulation often has been observed. When the females have matured sexually the oviposition immediately takes place and the larvae are found from the end of May. Hibernating adults with few exceptions die before the first summer generation of adults begins to appear towards the end of June. When this generation has matured sexually it gives rise to a second summer generation, the females of which never seem to become sexually mature in the same year. In the females of the first summer generation the ovaries develop during June and the beginning of July. To distinguish the first and second summer generation in the field is somewhat difficult, but the first one is paler on an average due to a lesser amount of accumulated melanin, mainly in the mesonotum. Whether single members from the first summer generation are included in the hibernating population, is not stated. However, as far as is known, no females with developed ovaries exist in the winter population before May which should have been expected if specimens from the first summer-generation had been present.

Spreading during the spring.

In order to investigate the spreading of Callicorixa producta during the spring, and also to correlate it with certain factors by some students supposed to release it, the following method has been used: Fifty specimens of C. producta were placed into the rock-pool of the type described in chapter IV A. Daily observations of the number of remaining specimens were made during May (Fig. 20). As it had been supposed that factors like air temperature, force of the wind, wave motions able to influence the vertical temperature gradient in the water, light conditions (Popham and Lansbury, 1960), influence the spreading, these factors were measured at the check-ups. No colour marking of the test animals has been made as this procedure may involve disturbances resulting in changed reaction pattern. The main purpose of the experiment was not to investigate a possible immigration of new animals into the rock-pool, but only the reduction of the number of specimens by emigration. No predators were present in the biotope. In two instances (May, 7th and 14th) new animals were added so as to restore the original number of 50 specimens. Observations and measurements were made daily at h 14. The air temperature has been measured in the shadow 30 cm above the surface of the rock-pool. In order to obtain an estimate of the vertical temperature gradient, the water temperature was measured both at the bottom (depth about 25 cm) and about 1 cm below the surface. The force of the

wind is given in meter per second and measured at 30 cm. above the surface of the rock-pool. By the estimate of light conditions, the entire period between two observations was taken into account, using the following classification: S = no clouds, (S) = glimpses of sunshine, clouds, (C) = mainly overcast, glimpses of sunshine at times, C = entirely overcast.

From the table, fig. 20, appears that mass migration occurred between May 6th and 7th, and between June 13th and 14th, under quite different conditions of weather, fair in the first instance and cloudy in the second. After this a small but continuous emigration from the biotope has taken place during the last third part of the period. The figures of the number of remaining animals naturally are not absolute, partly due to that it is not possible to find all the specimens at the check-ups, partly because single immigrants may have been added.

By many writers the temperature is considered to be the most important factor in releasing the dispersal of the Corixidae because an increase of temperature is thought to stimulate flight (Popham and Lansbury, 1960; Pajunen and Jansson, 1969.). The authors mentioned, however, have not made any measurements of temperature by their observations. It is evident from the table that migration in the two above instances were released without any previous increase of temperature neither of the water or the air. Similar results have been obtained in Great Britain with Sigara falleni and Sigara dorsalis (Young, 1966). Tolerance tests with the temperature as factor (chapter IV B.) furthermore show that the temperature has to exceed the values reached in the biotope in order to release migrations.

This particular investigation shows that single mass migrations occur early in the spring when the water temperature is low, and only to lesser extent later on when the water has become warmer. It is also seen that in one of these instances (May 14th) the sky was entirely overcast. In spite of this, observations indicating that migration of Corixidae only takes place during periods of sunshine have been made (Fernando, 1959; Young, 1966). This investigation, however, gives examples of Corixidae flying also during the night when light intensity cannot possibly act as a factor of spreading release (chapter V 3).

As has been mentioned, certain authors think that an increase of temperature leads to migration. The reason would be that by increased temperature the oxygen saturation of the water is diminished and consequently the effectiveness of the physical gill (Popham and Lansbury, 1960). The behaviour of the Corixidae would seem to indicate that they become

positively phototactic by lack of oxygen and faintly negatively phototactic by high oxygen amount. Light is absorbed on its way through the water especially in suspension and decreases with increasing depth. When there are no differences of temperature in the water, Corixidae normally swim downwards along this light gradient. On calm, sunny days the surface water is warmed most and this causes a temperature gradient. Under such conditions, Corixidae swim from the bottom up towards the warmer surface and in shallow water gather by the edge of the pool after which migration may take place. Even light winds disturb the temperature gradient through wave motions. Then, Corixidae do not gather at the surface and consequently migration fails to start (Popham and Lansbury, 1960).

From this particular investigation it is evident that the weather in the two obvious instances of migration, May 7th, and 14th, both with a loss of about 50 % of the population, was not characterized by increased temperature of water or air. The amount of oxygen under such conditions is no doubt sufficient. On account of the high transparency and the insignificant depth in the rock-pool, the temperature gradient was hardly noticeable (0.1 and 0.3 degrees, respectively) though the force of the wind and consequently also the wave motions were exceedingly small. The conditions on May 13th and 14th show that high light intensity or direct sunshine are not necessary for migration, at least not in all Corixidae. For this reason at least the typical spring migration seems to be an obligate phenomenon not released by changes in formerly discussed abiotic factors, but by an inner readiness. The exact time of the spreading, However, may change from one year to another depending on climatic factors as, quite naturally, a certain minimum temperature is required to enable the animals to fly.

Spreading May to October.

In order to obtain more facts about the spreading of the Corixidae during different seasons the following method was used. Five rock-pools on Sjöö were chosen and arranged according to the principles accounted for in chapter IV A. The location is seen on the map, fig. 21. The largest population of Corixidae in the area are found in the rock-pools of type 3 on Sjöö, located in the centre with the five artificial rock-pools grouped around at distances of between 0.3 and 3.0 m from Sjöö 3B, C and D, respectively. If Corixidae spread at short distance, it might be expected that animals migrate from the pools of type 3 to the five new ones close by. The purpose of this kind of arrangement was, furthermore, to eliminate

as far as possible the importance of the wind direction. Irrespectively of the wind direction at least one of the artificial pools is bound to be in the way of the wind coming from the central rock-pools. Outside of this inner zone of five rock-pools another zone of five pools was arranged in the same way. The pools of this zone are situated at distances of 2 to 3 m away from the inner ones. Originally the ten rock-pools were to be considered temporary rain-water pools for which reason the lowest threshold of passage was made higher by means of concrete in order to secure a more permanent water supply. The transparency was high, which is important when it comes to discovering newly arrived animals. The surface of the pools varied from 1 to 3 m² and the depth between 15 and 30 cm. Water lost by evaporation was substituted from pools of type 3. From these also was brought organic matter,, partly to make the bottom colour suitable (chapter V II), partly to serve as food supply which was completed with Chironomidae larvae, Once a week a check up of the ten pools in the test was made at which they were thoroughly examined and the animals present registered and removed. Most of them were put into one of the central rock-pools of type 3. The result of the investigation is presented in the table next page and in the diagram, figure 22. From these the following is evident:

Callicorixa producta

1. Spring. The greatest interest has to be connected with Callicorixa producta which is the only of the Corixidae species present that without doubt has stationary populations in the area. Although the density of these is rather low during May, when the population is made up by hibernating adults, still the collected material from this month is surprisingly large, with 212 specimens of C. producta arrived, in the inner and 96 in the outergroup. The total number of the whole period of May to October was 287 and 153, respectively, which means that out of the collected specimens of C. producta (normal form) 73.9 % arrived in the inner, and 62.7 % in the outergroup during May.

That the spring dispersal is completely predominant is thus quite clear. This is a great advantage to the species which in this way by the time for the oviposition can increase its distribution area through short distance spreading from a few hibernation biotopes.

The very much higher number of animals in the innergroup (212, as compared to 96 in the outer one) confirms that the animals largely emanate from the type 3 pools close by. Otherwise the number would have been equal in the two groups. Furthermore, all the flightless specimens were (cont.

Month	May			June			July			August			Sept.			October			Total number specimens						
	5	12	19	27	3	9	18	26	6	14	21	28	4	12	19	25	7	15		22	29	6	13	20	27
Date	36	73	90	13	7		4	6	8		3	16	7	10	3	6	4			1					287
C. " (flightless)							2	1	1	3			2	1			1								11
S. semistriata	3			1										4											8
S. nigrolineata				1						1			2				1	2			1				8
C. praeusta				1					1					1											3
H. sahlbergi				1			1					3													5
C. producta (normal)	23	19	37	17	3	4	8		2	3	23	5	3	3	2		1								153
S. semistriata				2										1											3
S. nigrolineata						1			1			1							1						4
C. praeusta							1							1											2
H. sahlbergi								2							1										3

inner group
of pools
a - e

outer group
of pools
f - j

Table showing dispersal of Corixidae to two groups of artificial rock-pools in Sjö33, 1969.

collected in the pool which is only 0.3 m away from 3C. These 11 specimens could not have come from any other habitat than 3C, partly because they are incapable of flying far enough, partly because the type apparently occurred only at Sjöö 3C in the years of the investigation.

2. Summer. During the reproductive period of June - July - August there is a rather continuous spreading, though to a small extent regarding the number of specimens. It is at its lowest in July which may be due to that hibernating adults have died by now and that in the first summer generation only few specimens have developed into adults. The rather high number of immigrants in the last week of July may be due to an occasional spreading from distant habitats.

The difference in the number of received animals in the pools of the inner and outer zone is not marked during this period, for which reason it is not certain that the majority came from the close-by pools of type 3 but very possibly may represent far away biotopes where migrations for some reason have been released. The few flightless specimens, however, still must have come from the close-by 3C.

3. Autumn. The figures for September and October are very low and it is not possible to trace any autumnal migration as has been observed in Finland (Pajunen and Jansson, 1969) and in Great Britain (Brown, 1951). The ten pools in this investigation, however, are small and for the reason they do not provide any good environments for hibernation of Corixidae which in Finland have been seen to accumulate during the autumn in great numbers in the large-sized and deep rock-pools into which they might even actively orientate themselves (Pajunen and Jansson, 1969). No such increases of the population density of the larger rock-pools have taken place during the autumn in the archipelago of Karlshamn, as is seen in appendix II.

Other species.

As has been mentioned, of the Corixidae present in the area only Callicorixa producta without doubt has stationary populations. Other species have been found sporadically in few numbers, possibly with the exception of Hesperocorixa sahlbergi which throughout the three years of the investigation. 1964 - 66, has occurred in Sjöö 3D, where 17 specimens were collected. Also during the period 1967 - 69 the distribution and abundance of the species has been the same.

Still it is of interest to notice that Sigara nigrolineata, Hesperocorixa sahlbergi, Callicorixa praeusta and Sigara semistriata in spite

of their very low frequency in the area do occur in the table repeatedly. At least S. nigrolineata, C. praeusta (Brown, 1951) and H. sahlbergi (Lansbury, 1961) have proved to have a very strong migration potential which also seems to be the case with S. semistriata.

In all, 11 specimens were collected of S. semistriata, 12 of S. nigrolineata, 5 of C. praeusta, and 8 of H. sahlbergi. The number may seem low in comparison with that of C. producta, but in the three first mentioned the number is higher than the total number of specimens collected by conventional methods in 1964 - 1966. For this reason it is very likely to consider these specimens at least partly a result of long distance flight.

5. Hibernation.

The winter 1969 - 70 was in southern Sweden characterized by its long duration resulting in the rock-pools being frozen already in the middle of November. This lasted, without any breaks, until the first week of April, that is, for about five months. Even the deeper rock-pools were frozen solid throughout February and in the first half of March, shallower pools for a longer period.

Throughout the winter observations have been made continuously, mainly at Sjöö, partly because this island can be reached from the mainland under all conditions, partly because the rock-pool of Sjöö 3C is the largest and deepest of all pools in the investigation area. Furthermore, throughout the investigation period it has possessed a stationary population of Callicorixa producta. On account of its volume and ample supply of organic bottom matter abundant in Chironomid larvae, it must be considered the best habitat of hibernation for C. producta in the area. In the bottom of the pool there are crevices in which Corixidae have proved themselves able to survive during months of freeze-up. The occurrence of C. producta in Sjöö 3C in 1969 and 1970 is shown in the diagram, fig. 23. The specimens that were found after November and up to February were in the bottom material which was frozen in February. These were almost motionless specimens which, however, regained normal activity after having been transferred for some hours in water of 18° C.

During the period March until the first week of August, 1970, no Corixidae were found in Sjöö 3C nor in any other examined rock-pool. The population of C. producta, in preceding years stationary, had apparently become entirely extinct during the winter 1969 - 70. The last observation of Notonecta glauca at Sjöö 3C was made in October 1969 after which

the species was not found in any of the examined rock-pools. Of all the species formerly present in the rock-pools of the area only Chironomid larvae succeeded in hibernating.

In a check-up of the whole investigation area during the first week of August 1970, until August 7th, no Corixidae were found.

On the 9th of August numerous Callicorixa producta were found in Sjöö 3C, in the adjacent pool 3D, and also in several of the other rock-pools situated on other islands. C. producta occurred in varying number ranging, in part abundantly. All specimens examined belonged to the second summer generation and had fully developed flight muscles (see chapter V. 6).

No larval forms were observed now, nor later during the year. The weather conditions between August 7th and 9th were characterized by weak, varying winds, day temperatures between 17 and 19° C and dry weather. The sudden occurrence of C. producta should be considered as a result of mass migration released in some distant area where the species had hibernated.

6.. Flight muscle dimorphism in Callicorixa producta.

Almost all Corixidae existing in Great Britain are said to be wing - or, usually, wing muscle polymorphic ("flight polymorphism"; Young, 1965). It would perhaps have been more appropriate to call it dimorphism. The few species not showing polymorphism belong to a group characteristic of the coenosis in temporary pools of water (Young, 1965). These species must, after all, always have a possibility of emigrating to a new environment when the biotope does not offer suitable conditions of life, which cannot be done in the flightless form.

Most of the flight polymorphic species have normally developed wings although with reductions in the flight muscles (Young, 1965).

Among the Corixidae present in this investigation, Callicorixa praeusta, Hesperocorixa sahlbergi and Sigara nigrolineata have not proved to be flight polymorphic in Great Britain, and the same observations have been made in the archipelago of Karlshamn. The species mentioned occur, however, so infrequently that the material investigated cannot be the basis for an absolutely correct estimate. The specimens that have been found there probably have been occasional guests from biotopes remotely situated and consequently specimens with flying ability.

Callicorixa producta, the main subject of my observations, does not occur in Great Britain.

All the four species mentioned often occur in temporary waters. Thus, according to reasons given above, they should not show flightless varieties. This, however, is the case with Callicorixa producta, which in

spite of being a typical species of rock-pools with great spreading potential occurs both as normal and as flightless in the archipelago of Karlshamn. Other species of Corixidae in the area have not been subjected to a more close investigation in this respect but as flightless forms of Corixidae, at least in the first summer generation, are easy to recognize on their characteristic yellowish-brown colour, observed only in C. producta, it is improbable that other species occur in the form with reduced muscles.

Pigmentation and development of the flight muscles in C. producta begin as soon as the animal leaves the final fifth larval stage and takes place gradually with the exception of elytra and pronotum, the pigmentation of which is finished only a few hours after the animal has reached the adult stage. The amount of stored melanin in these organs is dependant upon the nature of the bottom colour (Popham, 1941). Concerning the development of muscles and pigmentation of the other parts of the body, this is extended over a rather long period, in the archipelago of Karlshamn lasting between 15 to 30 days, depending in the first place on the temperature during the period in question.

Differences of pigmentation in various generations of Callicorixa producta.

First summer generation:

General habitus. This generation, starting as adult in June, taken as a whole has a fainter pigmentation than the second summer generation, appearing yellowish-brown compared to the latter, which is dark brown to black. Because of this they can be roughly separated in the field, particularly in the beginning of the period when the second summer generation starts becoming adult, as there often is a certain extra pigmentation in arrears, of the first generation producing a darker shade. In order better to ascertain to which generation a specimen belongs it is advisable to examine the internal genitalia as at least the females of the second generation do not reach sexual maturity during the first year.

A. The normal form: The lateral and hind parts of mesonotum are pigmented only in patches and faintly. The remaining parts of mesonotum are pale brown, which also applies to the rest of the dorsal side with the exception of pronotum, the colour of which is dark brown. The ventral side has no pigmentation with the exception of thorax which is pale brown.

B. The flightless form: The front part of mesonotum is a pale brown while the lateral and hind parts lack pigmentation. The other parts of the body are of a very faint pigmentation, also the pronotum, for which reason the animal as a whole gives the impression of being yellow. Due to the extra pigmentation in the arrears mentioned above, this is more pronounced at the beginning of the adult stage.

Second summer generation:

General habitus. This generation in its two forms is of a very dark brown to black, particularly on the dorsal side. Differences in colouring between normal and flightless specimens mostly relate to the hind part of mesonotum.

A. The normal form: Mesonotum black, but with the hind and lateral margin in part of a pale brown.

B. The flightless form: Only the front part of mesonotum black, the rear half without pigmentation for which reason it gives the impression of being pale yellow.

Differences in the development of flight muscles in normal and flightless forms of *Callicorixa producta* (fig. 24).

A. The flightless form (fig. 24 B and D): It is the indirect flight muscles situated in mesothorax that are degenerated in the flightless forms of both generations, more exactly the following three pairs: the median dorsal longitudinal flight muscle (M 30), the lateral dorsal longitudinal flight muscle (M 31), and the tergal sternal flight muscle (M 34). (Designations according to Larsén, 1945.)

The biggest muscle, M 30, like M 31, is attached at notum and the second phragma while the zones for attachment of M 34 are situated in notum and sternum. All of them are strongly reduced though thickened through their terminal parts close to the attachment zones. This is particularly obvious with M 30 and M 34 where about 75 per cent of the cross-section surface of the normal muscle is left; in M 31 the bulge at the attachment is of less dimensions.

In flightless specimens the organs in the thorax are of an almost white colour, in part due to the fact that the remaining muscles are very pale compared to those of the normal variety, in part due to the fact that the space between the atrophied muscles is filled up with layers of fat and connective tissue of a whitish colour.

B. The normal form (fig. 24 A and C): The muscles have the same cross-section surface throughout their whole extent without any bulging parts at the attachment zones. The muscles fill up the whole of mesothorax for which reason layers of fat and connective tissue do not occur to any significant extent. The muscular fibres are of a yellowish colour.

Proportions of the different forms of *Callicorixa producta*.

Observations on the proportions between respectively normal specimens and flightless specimens from the different generations have been subjected to investigations during 1968 and 1969. Before the year of 1968 no flightless specimens were seen. The observations have been limited to rock-pool 3C at Sjöö as this is the only habitat where flightless specimens have been found. The reason for their absence even in rather similar and adjacent pools could be the poor capacity for spreading of this form. But the very fact that this form has been found only in a single rock-pool is interesting from other points of view, and will be treated separately further on.

Examination technique.

In order to obtain a measure of the proportions in Sjöö 3C between normal specimens and flightless specimens, respectively, it was first studied whether the two forms in some way show different behaviour by staying at different levels from the surface downwards, by distributing differently in respectively the shadowy part or the sunlit part of the pool, or if the two forms showed a preference for various bottoms as regards varying colour of body and background. No such distinctions, however, could be found. The two forms were freely mixed in the pool.

Then the catching could begin, performed by means of a water net, the diameter of which was 30 cm. It was drawn through the water at three different levels, five times at each, and the number of animals caught at each level were counted.

Result:

Second summer generation (hibernated). April, 15th, 1968.

	Number of specimens of normal form	Number of specimens of flightless form
1. At surface	6	0
2. At 0.5 m	4	0
3. At bottom	9	0

Second summer generation (hibernated) April, 13th, 1969.

	Number specimens of normal form	Number specimens of flightless form
1. At surface	8	0
2. At 0.5 m	8	0
3. At bottom	13	0

First summer generation. June, 27th, 1968

	Number specimens of normal form	Number specimens of flightless form	Per cent specimens of flightless form
1. At surface	16	1	6.3
2. At 0.5 m	32	3	9.4
3. At bottom	75	8	10.7

Total amount: 123 normal form, 12 flightless form (9.8 per cent)

First summer generation. June, 30th, 1969.

	Number specimens of normal form	Number specimens of flightless form	Per cent specimens of flightless form
1. At surface	18	2	11.1
2. At 0.5 m	44	4	9.1
3. At bottom	96	10	10.4

Total amount: 158 normal form, 16 flightless form (10.1 per cent).

Second summer generation. September, 15th, 1968.

(Specimens belonging to 1st summer generation were removed).

	Number specimens of normal form	Number specimens of flightless form	Per cent specimens of flightless form
1. At surface	18	2	11.1
2. At 0.5 m	63	4	6.3
3. At bottom	128	7	5.5

Total amount: 209 normal form, 13 flightless form (6.2 per cent).

Second summer generation. September, 21st, 1969.

(Specimens belonging to 1st summer generation were removed)

	Number specimens of normal form	Number specimens of flightless form	Per cent specimens of flightless form
1. At surface	16	3	18.8
2. At 0.5 m	50	7	14.0
3. At bottom	97	9	8.1

Total amount: 163 normal form, 19 flightless form (11.7 per cent).

From investigations in Great Britain (Young, 1965) on species of Corixidae occurring in more static water than that of rock-pools, it is evident that in the first summer generation the flightless form dominates numerically. In the second summer generation, however, the abundance of normal specimens was clearly the greater. There were certain variations in this respect among various species, also the type of biotope seemed to play a part in this.

As is seen from the tables, the flightless form of Callicorixa producta occurred rather infrequently. About 10 per cent of the specimens belonged to this group. But as the species in this area is a typical species of the rock-pools and consequently must have a good migration capacity the flightless variety can hardly occur to a very great extent as the population in that case would become extinct during unfavourable conditions in the biotope. The pale flightless animals are easily visible in dark water rich in humus as they contrast against the dark bottom colour more than the dark normal form. In the rock-pool 30 a predator is present, that is Notonecta glauca, and it would be possible that a selection takes place favouring the normal form at the expense of the flightless form as this to a greater extent would be the prey. In that case this would be a reason for the flightless form not occurring to any great extent. In order to investigate this 20 dark normal specimens and ten pale flightless specimens were placed in a rock-pool otherwise empty of Corixidae. The surface of the pool was about 1.5 m² and the depth 25 cm. The bottom of the pool was dark and held organic matter in which there were Chironomidae larvae, also a prey of Notonecta glauca. In the pool was placed 6 N. glauca. To keep outside specimens of Callicorixa producta from disturbing the result a small-meshed net was put over the rock-pool. The result is shown in the table on the next side.

	20 normal	10 flightless	Normal. Loss in 24 hours	Flightless. Loss in 24 hours
Number of <i>C. producta</i> lost after first day	7	3	35.0 %	30.0 %
Number of <i>C. producta</i> lost after second day	4	1	36.9 %	14.3 %
Number of <i>C. producta</i> lost after third day	5	3	55.6 %	50.0 %

Total amount: loss of the normal form in three days, 80.0 per cent,
loss of the flightless form in three days, 70.0 per cent.

The result of the test does not give cause for supposing the flightless form to fall a prey to such a predator as Notonecta glauca more than the normal form does. As the investigation only covers a small amount of the test material and is of rather short duration no conclusions which are to far-reaching can be drawn from the result, though contrary to expectation the flightless variety shows the lower number of loss. Young (1965) has shown that the muscles of the legs are better developed in the flightless form. This fact may be one reason for the flightless specimens avoiding the attacks of the predators to a greater extent than the normal specimens do.

Spreading behaviour in the two forms of *Callicorixa producta*.

In order to examine whether there are any differences in the response of the two forms to unfavourable environmental changes, temperature was used as a factor and a test with successively increased temperature was performed in the following manner. Into a hollow, moulded of concrete and painted a dark brown, was poured water from a natural rock-pool and this was tolerated in every way by *C. producta*. The edges of the "pool" were made flat and rough to make it easy for the animals being tested to creep out of the water. The surface was about 0.4 m^2 and 10 cm at the deepest. The water was warmed through immersion-heaters screened off by glass-wool so as to keep animals too close by from being hurt by the high temperature. The temperature was increased by about one degree centigrade every ten minutes. Into the pool were brought 40 specimens of *C. producta*, 20 normal, 20 flightless, both of the forms belonging to the first summer generation.

The purpose of the test was as follows: (a) to find out whether the flightless form shows any migration tendencies at all when the temperature gets too high; (b) to observe in what way possible attempts at migration occur in flightless animals; (c) to compare tolerance and

and behaviour of the two forms.

For the investigations the same method was used as has been shown at the temperature tests in chapter IV. All attempts at migration were counted, and all migrating specimens restored to the test pool after which they can participate again. The result is evident from the table below and also from the diagram, fig. 25.

Temp. C°	Number migrations of normal form.	Number migrations of flightless form.
23 - 26	0	0
26 - 28	0	0
28 - 30	0	0
30 - 31	0	0
31 - 32	3	0
32 - 33	3	1
33 - 34	26	7
34 - 35	43	71
35 - 36	47	80
36 - 37	17 (reduced vitality)	76
37 - 38	0 " "	23 (reduced vitality)
38 - 39	0 " "	4 " "
39 - 40	All specimens dead	All specimens dead
Total	139	262

Result: All the migrating specimens tried to leave the pool flying from the brink of the water. Also the flightless form is able to perform sort of jumping flight but the length of it is very short, on the average about 15 cm. Under favourable conditions they may repeat such a flight, but rarely more than once. The average length of the migration distance, including creeping is less than 0.5 m, for which reason its possibilities to find a new suitable biotope must be considered very small. The distance between two rock-pools in an area of a character similar to the archipelago area in question, very often amounts to several meters, at times considerably more.

As is seen from the diagram (fig. 25), the two forms do not respond similarly to an increase of temperature. The normal variety responds with attempts at flight by a lower temperature than does the flightless form and furthermore it has, judging from the result, a lower resistance to high temperature. The flightless group reacts at a higher temperature

Than the normal group, responding very suddenly, also it tolerates a somewhat higher temperature before the tendencies of exhaustion set in.

Experiments on the possibilities to modify the flightless form of *Callicorixa producta* into the normal form by changes of environmental factors.

In Great Britain larvae of the flightless form of certain Corixidae have been taken at the final, fifth, larval stage, in some species even just emerged adults, and by increased temperature made to develop into the normal form with its typical pigmentation and well developed flight muscles. The result has most easily been achieved on larvae, as the larval stage seems to hold greater possibilities for modificatory adaptations in response to an environmental change than is the case with the adults in which after all the organs rapidly are fully developed.

It is not possible to trace any differences, anatomical or otherwise visible, in the larvae under natural conditions predestinated to develop into flightless adults or these which would be the origin of the normal form. In the British experiments it has been established that in certain species the early larvae giving rise to the first summer generation, mainly develop into the flightless form. Then this larvae have been used in the tests.

The procedure cannot be applied to *C. producta* in Blekinge of which the flightless form only constitutes about ten per cent, furthermore occurring solely in one rockpool. Under these circumstances it is necessary to concentrate on recently adult specimens and from such a population to sort out the animals which already show the pigmentation of the flightless form on their elytra. The sorting cannot be wholly reliable with the difference of colour as single criterion, because occasional recently adult animals of the normal form may show exceptionally pale elytra. As, unfortunately, the animals would be hurt it is not possible to examine the pigmentation of mesonotum, which otherwise would have been preferable.

Furthermore it is necessary to keep going a culture of caught larvae in order to obtain recent adult animals. This has been done in artificial rock-pools of the type earlier described. All the significant factors, as well abiotic as biotic, have been adapted so as to make the conditions correspond with those of the natural rock-pool Sjöö 30.

Before it is established that an increase in temperature will cause changes of a certain kind in a species it should be investigated whether other factors are changed as a consequence of the increase in temperature.

One such factor is the saturation of oxygen in the water which decreases by increased temperature. This must be most important to animals like C. producta that at least partly supplies its oxygen by means of a physical gill. Species, the entire oxygen supply of which is maintained from oxygen dissolved in the water, of course are still more dependant on this for which reason the value during the experiments must not be too low. Larsén (1931) has described one such case where in the wingpolymorphic species Aphelocheirus aestivalis (Hemiptera) the development of the wings is related to the amount of gas in the water.

In the present investigation low values of oxygen saturation, the result of increased temperature, have been compensated with a supply of air. Because of this it has been possible by the analysis to disregard the effect which a possible lack of oxygen might cause concerning modifications of the flightless form into the normal form.

Technique of experiment. The material used for the test consisted of specimens of the flightless form, first summer generation, of C. producta. The specimens had been adult for only a short while, between 6 and 24 hours. The investigation was performed under roof in order to obtain tolerably constant environmental conditions during the experiment. A warm and dry period with strong insolation would have made impossible all attempts at keeping a sufficiently low temperature in the pool, and heavy rain might have washed away the animals.

Into each of three concrete pools was filled water and food was supplied in the form of algae (Spirogyra sp.) and also organic matter containing Chironomidae larvae. The temperature was increased by immersion-heaters to the desired amount, the heaters being screened off by glass-wool. In all the pools the saturation of oxygen was kept at values between 110 to 125 per cent by means of supplying air in the way generally used in aquaria. Into every pool were brought 12 of the specimens being tested. The experiments were repeated for two years.

Callicorixa producta. Development into the normal form at different temperatures.

Pool I, 1968, temperature 15 to 18° C (no heating): No specimen was modified during the 30 days of experiment.

Pool I, 1969, temperature 15 to 19° C (no heating): Same result as was achieved in 1968.

Pool II, temperature 22 to 24° C.

Time of observation. 12 spec. (Number of days after that the test has started)	10	15	20	25	30	Total
Number of observed specimens developed into the normal form:						
1968	0	0	3	7	0	10 (83,3%)
1969	0	0	0	9	0	9 (75.0%)

Pool III, temperature 26 to 28° C.

Time of observation. 12 spec. (Number of days after that the test has started)	10	15	20	25	30	Total
Number of observed specimens developed into the normal form:						
1968	0	1	6	3	1	11 (91,7%)
1969	0	3	6	2	1	12 (100%)

A series of investigations of a similar kind as the one described above with the temperature as main factor was made in 1968, though with first summer generation flightless specimens, adult for at least a fortnight in order to find out whether high temperatures also in this could give a stimulus to a development towards the normal variety with respect to muscles and pigmentation. The result was unequivocal. Not in any single one of the 12 specimens being tested in each of the series of tests could any development towards the normal variety be discovered during the 30 days of the experiment, nor were there any differences between specimens which had experienced 22 to 24° C or 26 to 28° C, respectively.

In order to find out whether also a low content of oxygen has any modificatory influence on fresh adult animals belonging to the flightless form of the first summer generation, an investigation has been performed parallel with the test series described above with the temperature as a modificatory factor.

In this as in the temperature experiment the methods aimed at isolating

one factor from the others which is somewhat abnormal as in a natural rock-pool temperature is the most important of the abiotic factors on which the oxygen saturation largely depends.

In order to make an environment with a rather low oxygen content but at normal temperature with the maximum about 20° C., a spherical, transparent plastic globe was used as aquarium. Its volume was about 50 litres and it had a circular opening of about 1 dm^2 . The advantage of this small opening was that when the globe was filled with water, the surface contact between air and water was relatively small and the oxygen reception insignificant. Furthermore the spherical form of the aquarium guaranteed that the animals being tested always would find the opening when respiring as they were automatically guided that way along the bending interior wall.

The aquarium was entirely filled up with water from the rock-pool Sjöö 3C, from which also was brought organic matter with Chironomidae larvae. Some water plants (Elodea canadensis) were added. The water was changed several times during the 30 days of experiment. As is evident from fig. 8, the oxygen saturation normally alters very strongly in a rock-pool during 24 hours, also there are considerable differences at different levels. The oxygen saturation at the bottom of deep rock-pools often is extremely low, which fact also is indicated by the abundant presence of Chironomidae larvae with hemoglobin. As Corixidae to a great extent stay in the bottom layer where they find their food, one might suspect that they have a high tolerance towards a low content of oxygen.

As a suitable average value in this test a saturation value between 60 and 70 per cent was chosen. It is about equal to the lowest average values found in shallow as rather small rock-pools, in which there is no noticeable stratification as regards the content of oxygen.

In order to keep the oxygen saturation of the globe at the mentioned value, it was necessary to increase it by means of a slight current of air when the saturation tended to become too low. There were daily check-ups in the globe. During the time of the test, temperature varied between 15° and 19° C. The material of the test consisted of 12 flightless first summer-generation specimens of C. producta, all of which had been adults for no more than 24 hours by the time the experiment was started.

The result of the examination. Not one of the animals in the test developed towards the normal variety during the 30 days of the test. Three of them died during the test.

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Fig. 1. Map of the archipelago of Karlshamn.
Areas of investigation marked with black.



Fig. 2.



1. Type 1 rock-pool.

2. " 2 " "

3. " 3 " "

A. Normal level of sea.

B. High-water level of sea.

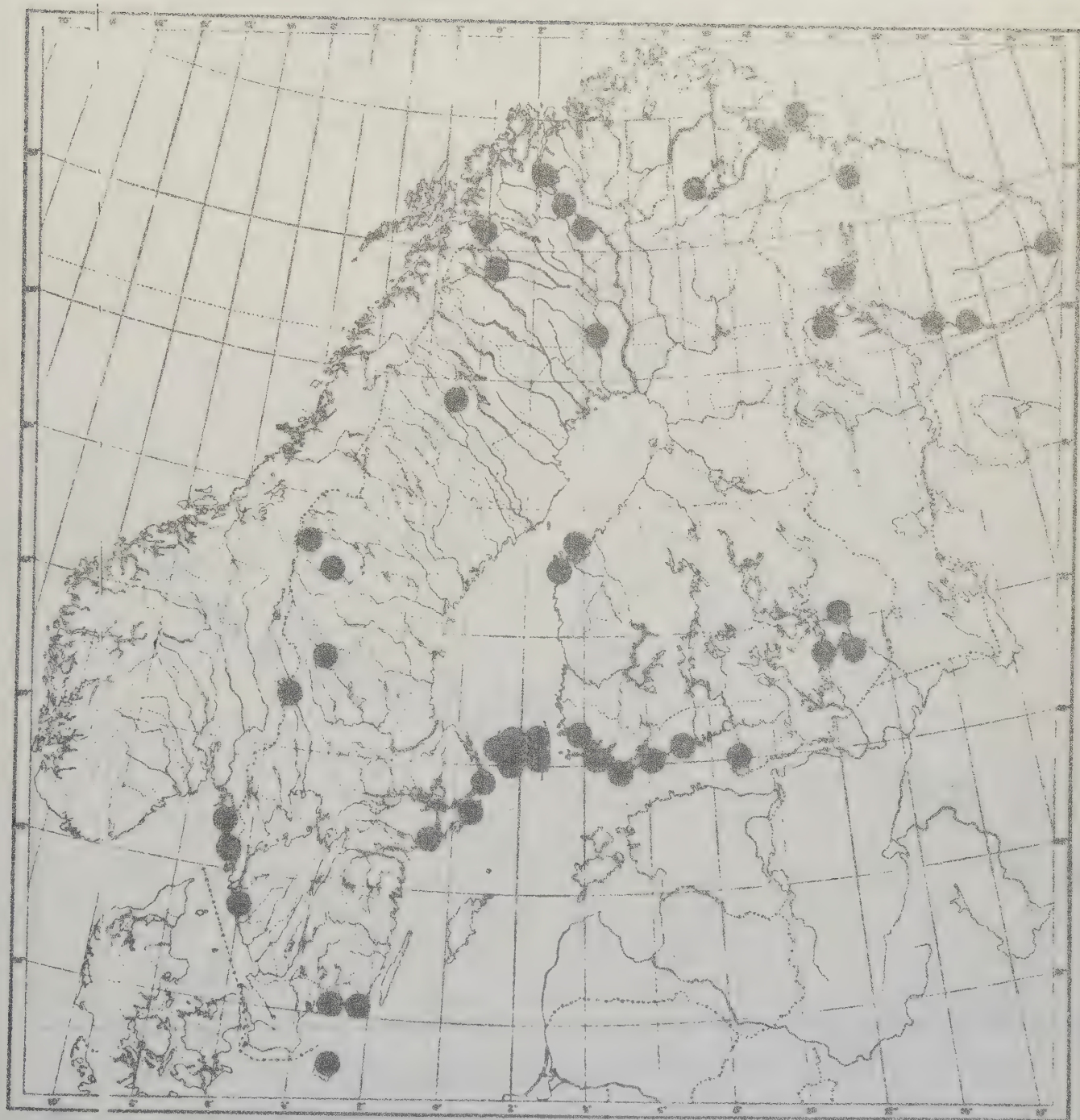
C. Rock with lichens or no vegetation.

D. Rock with scattered vascular plants.

E. Limit of the continuous vegetation.

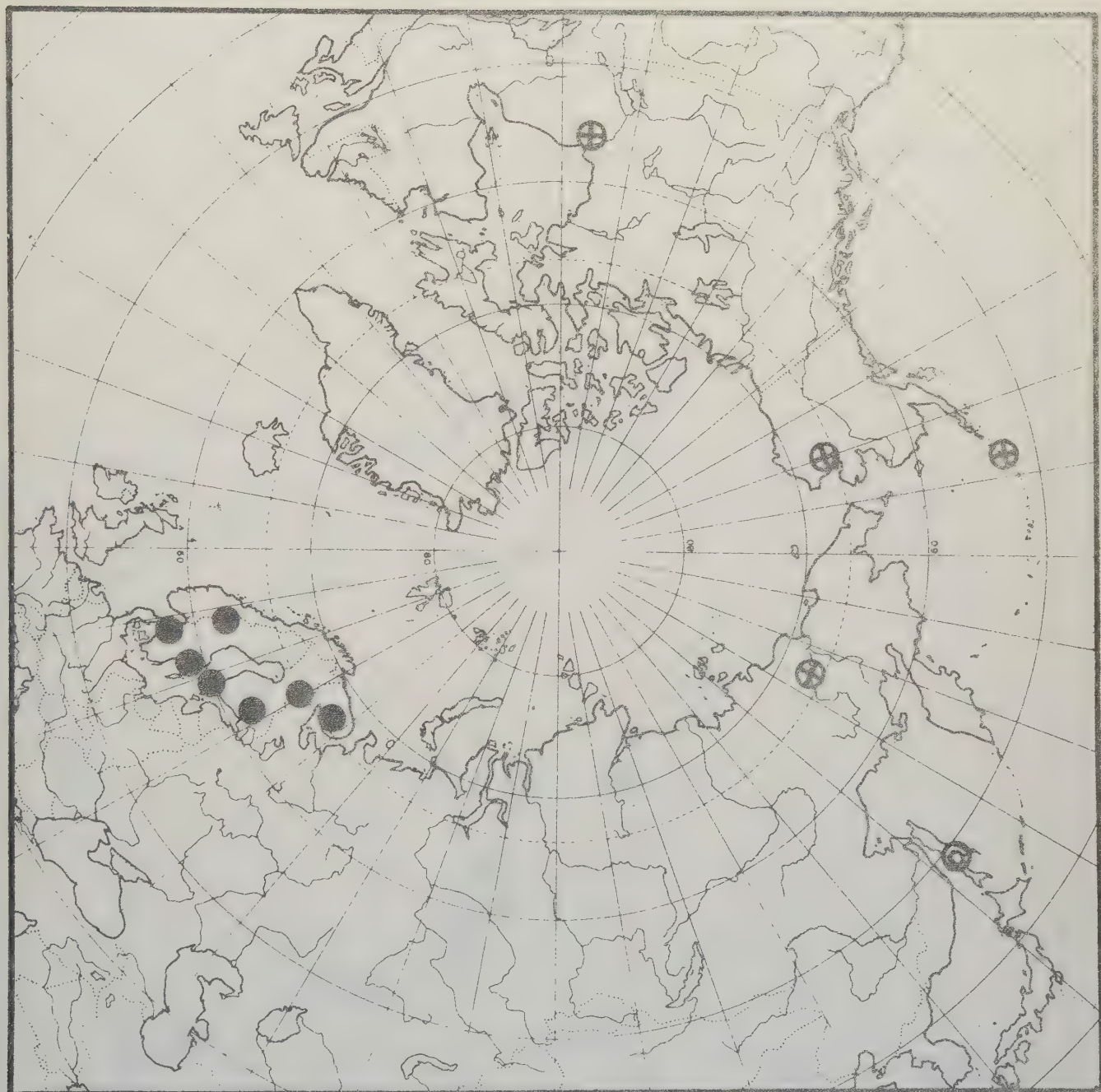
Vertical section showing main location of the three types of rock-pools described in the text.

Fig. 3.



Distribution of *Callicorixa producta* in Fennoscandia and Denmark.
(Mainly from H. Lindberg, 1944).

Fig. 4.

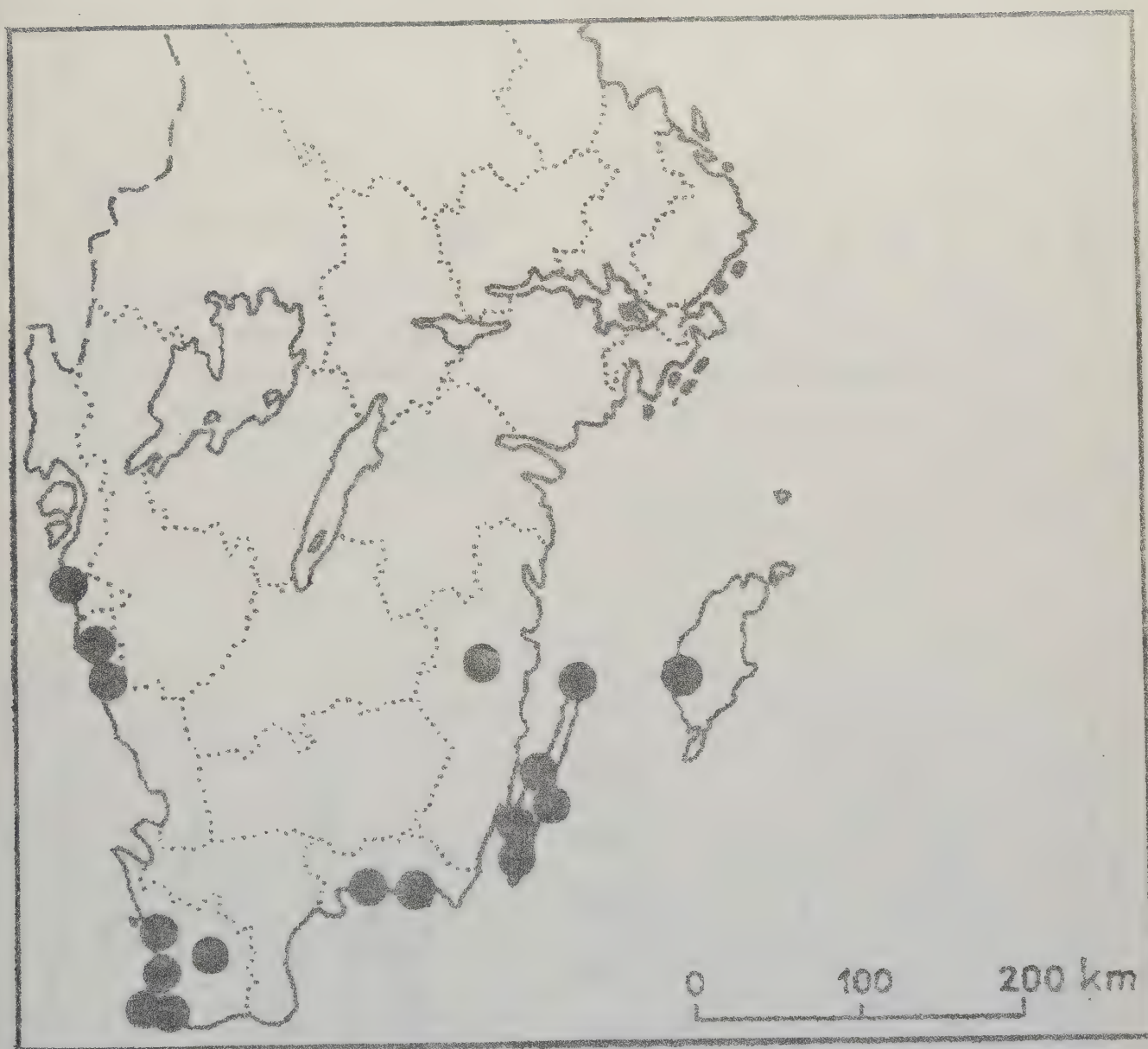


World distribution of Callicorixa producta. (After H.B. Hungerford, 1948).

● *Callicorixa producta* (Reut.)

⊕ *Callicorixa producta norvikensis* (Hungerford)

⊙ *Callicorixa producta sackalinensis* (Matsumura)



Distribution of Coelambus parallelogrammus in Sweden.

‰ salinity.

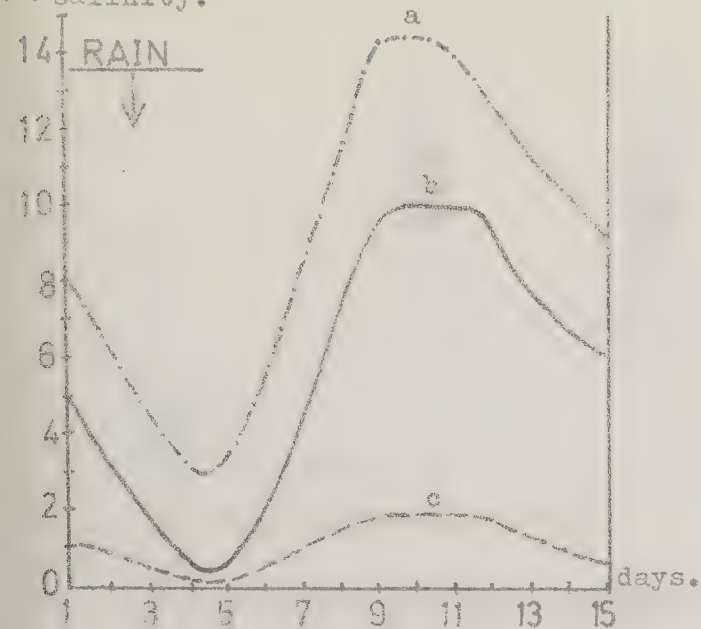


Fig. 6. Variation in salinity in the three types of rock-pools during a period of 15 days, July 1967.

a: Type 1 rock-pool. - b: Type 2 rock-pool. - c: Type 3 rock-pool.

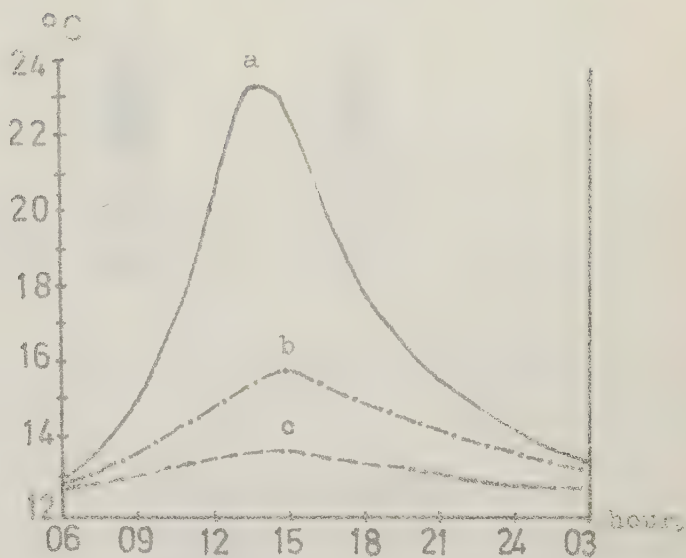


Fig. 7. Variation in temperature during 24 hours in Sjö 3 C. August, 4th, 1967.

The weather conditions were characterized by strong insolation during the day and high radiation during the night.
a: Depth of 1 cm. - b: Depth of 20 cm. - c: Depth of 150 cm.

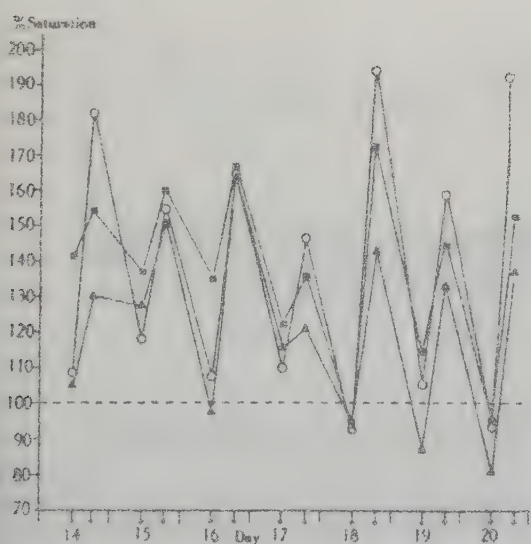


Fig. 8. Daily changes in the amount of oxygen in three rock-pools in Wales. (From Pyefinch, 1943).

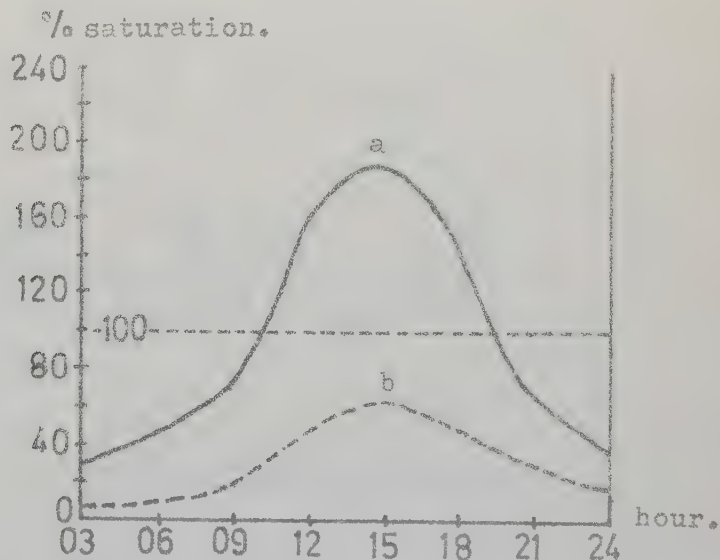


Fig. 9. Oxygen saturation during 24 hours in Sjö 3 C. August, 4th, 1967.
a: Depth of 1 cm. - b: Depth of 50 cm.

Fig. 10.

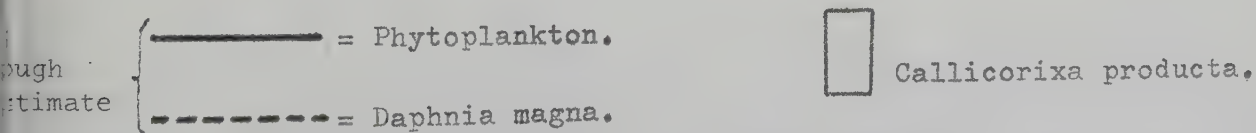
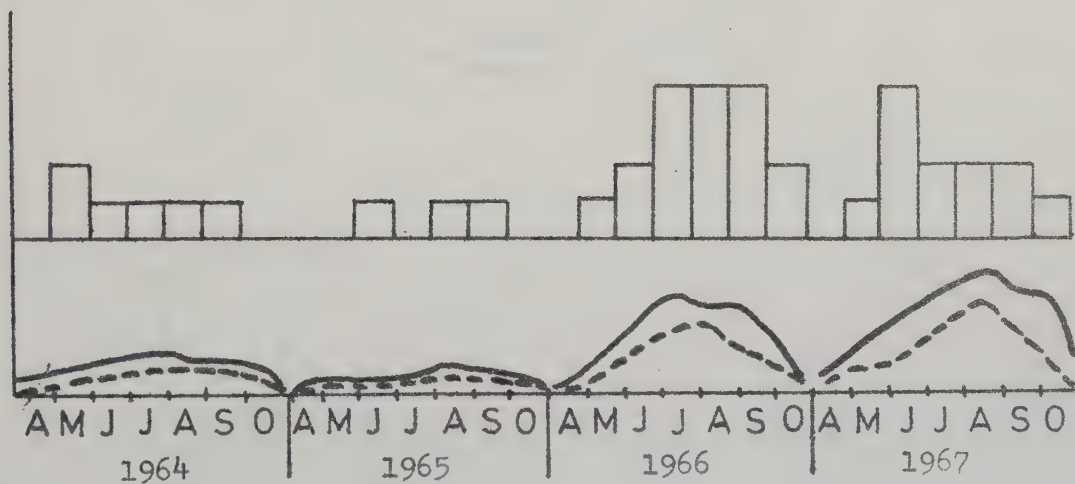
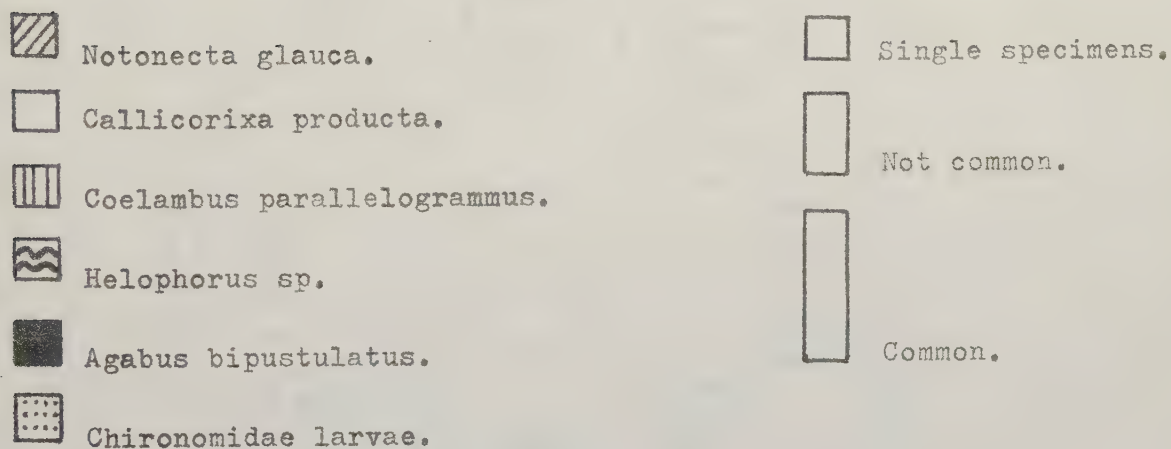
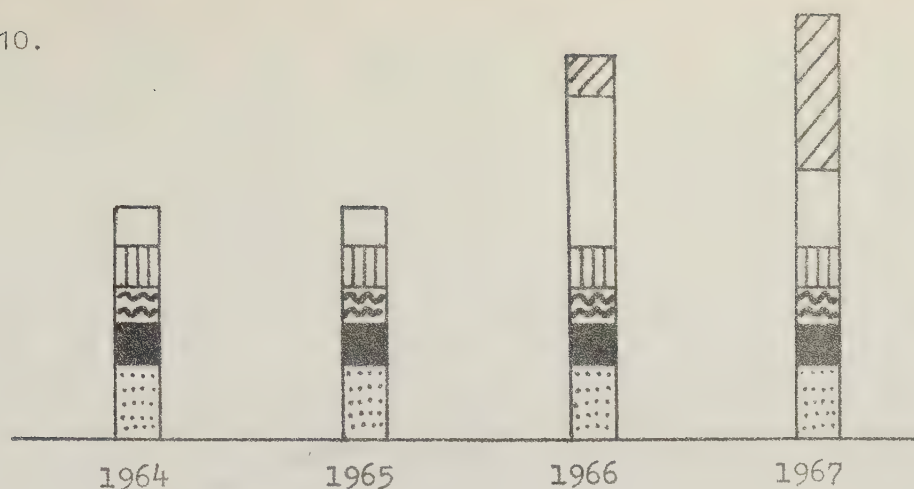
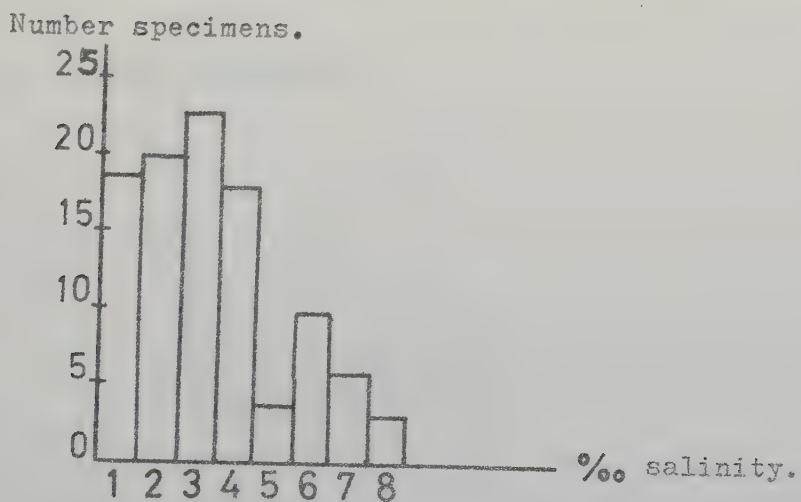
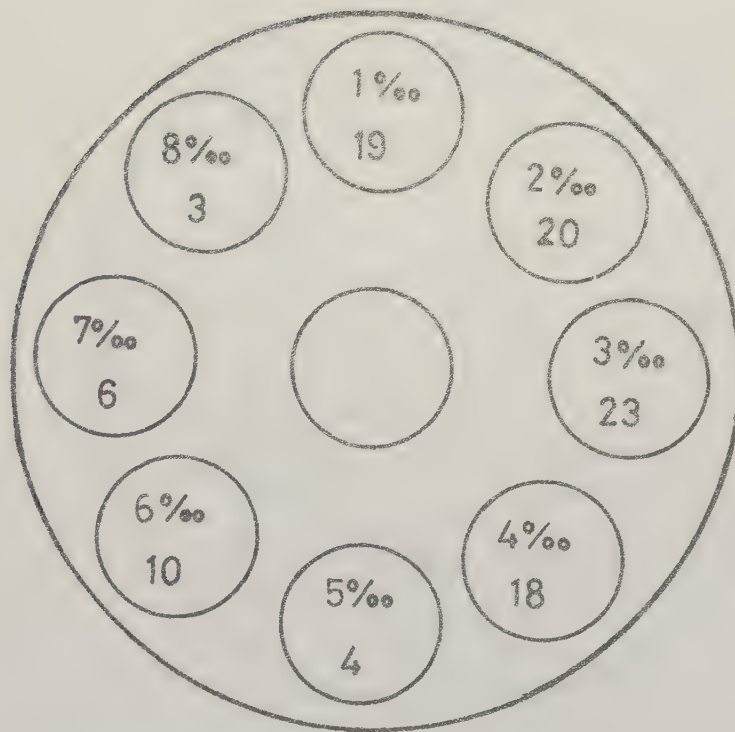


Fig. 10. Examples of fauna succession in a rock-pool of type 3 (see text, p. 24).

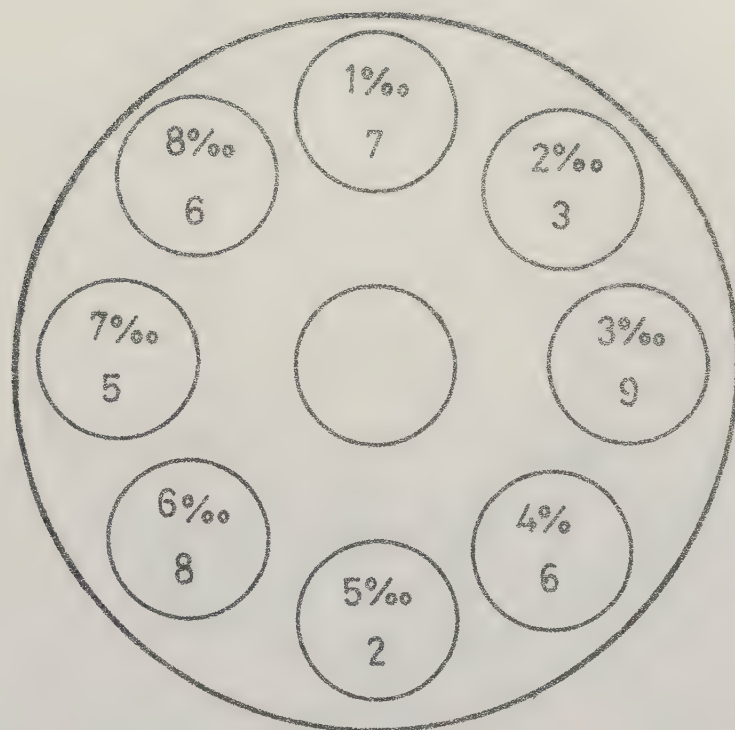
Fig.11.



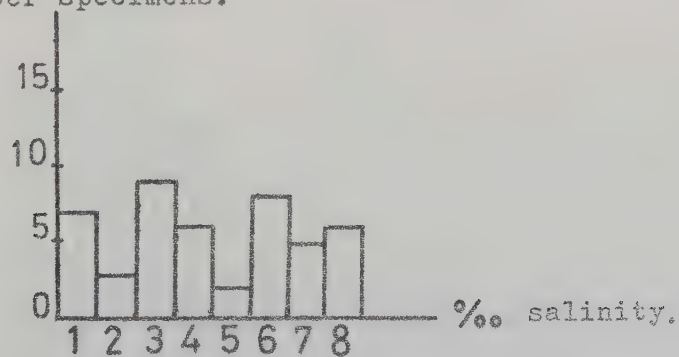
Experiments concerning salinity preference. Callicorixa producta.

The top figure and the staple diagram show the distribution of 103 specimens provided with the choice of salinity between 1 to 8 per mille.

Fig. 12.



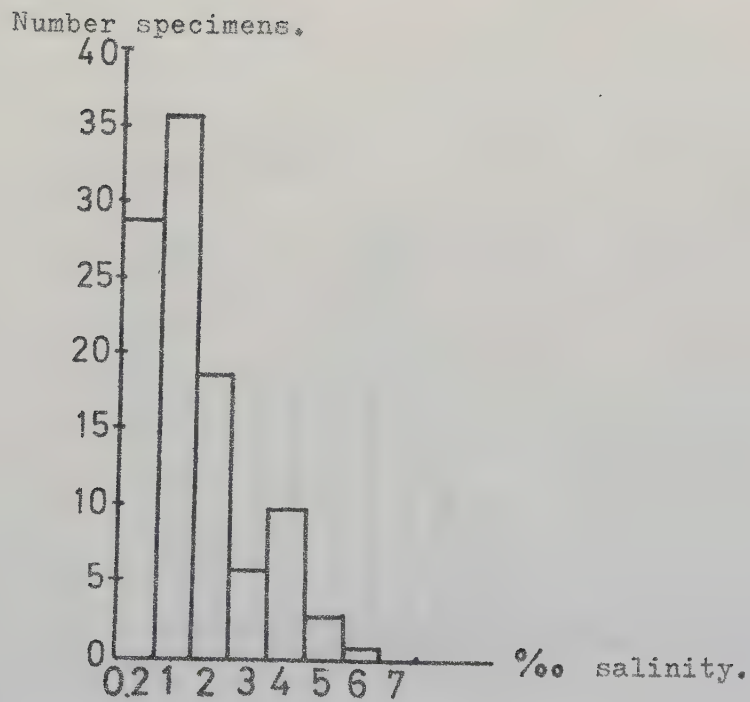
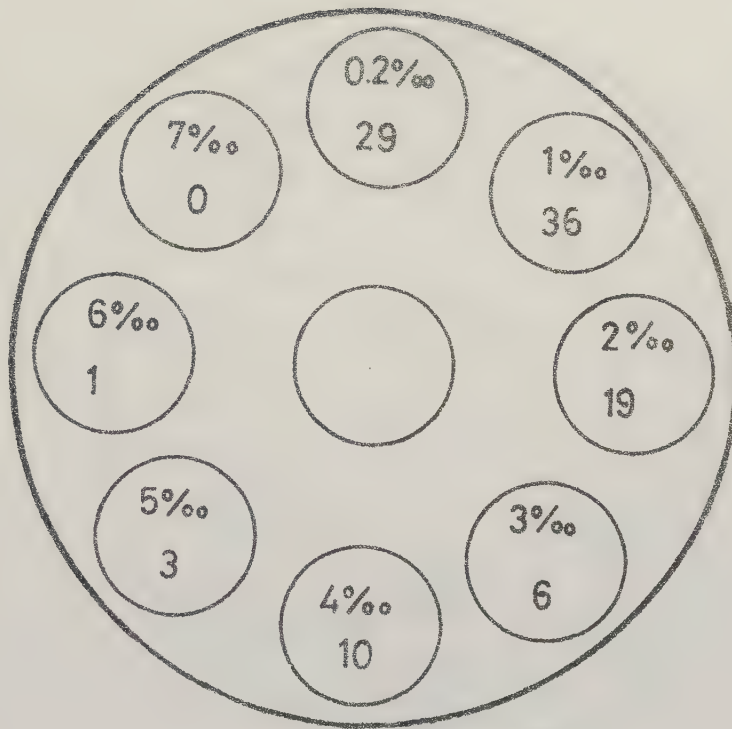
Number specimens.



Experiments concerning salinity preference. Notonecta glauca.

The top figure and the staple diagram show the distribution of 46 specimens provided with the choice of salinity between 1 to 8 per mille.

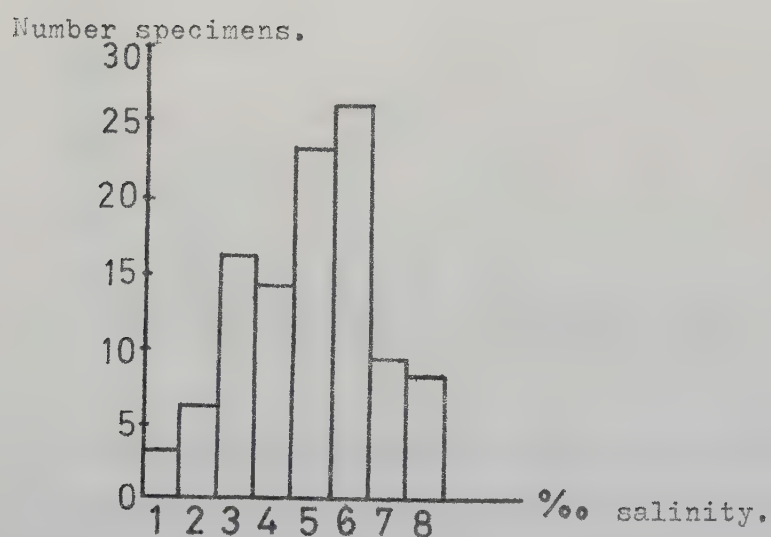
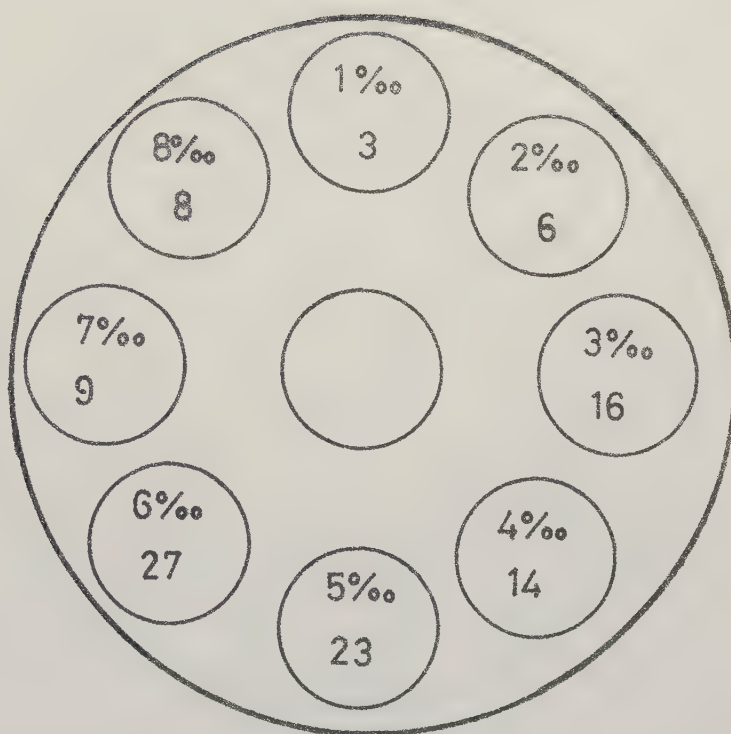
Fig. 13.



Experiments concerning salinity preference. Agabus bipustulatus.

The top figure and staple diagram show the distribution of 104 specimens provided with the choice of salinity between 0.2 to 7 per mille.

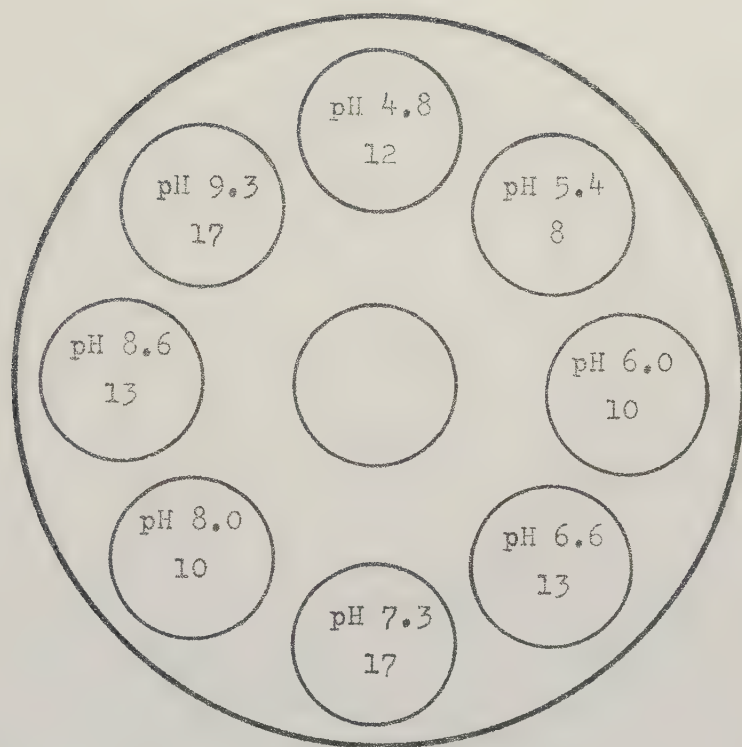
Fig. 14.



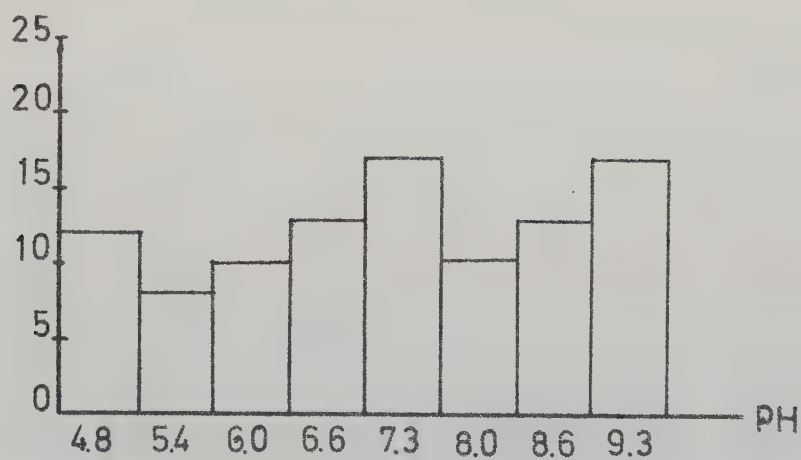
Experiments concerning salinity preference. Coelambus parallelogrammus.

The top figure and staple diagram show the distribution of 106 specimens provided with the choice of salinity between 1 to 8 per mille.

Fig. 15.



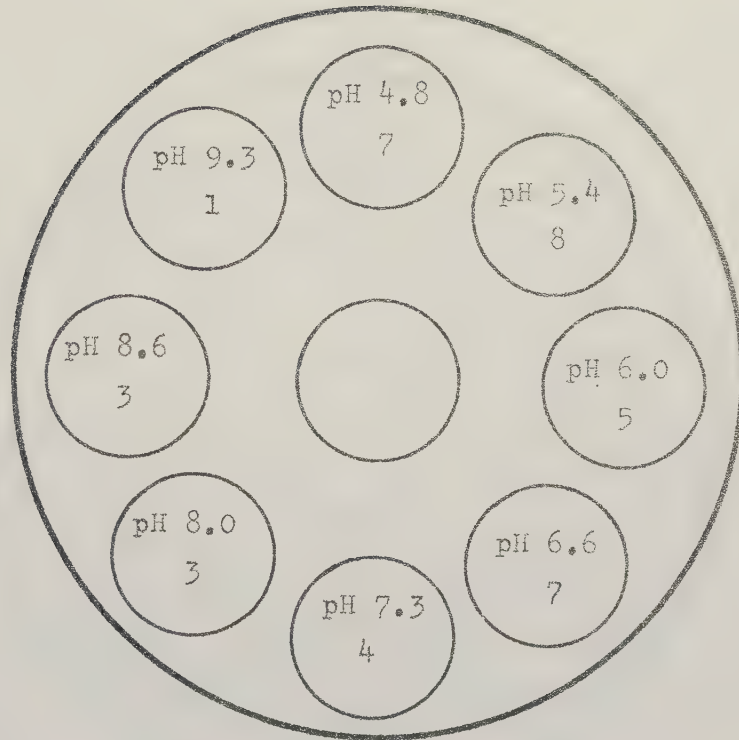
Number specimens.



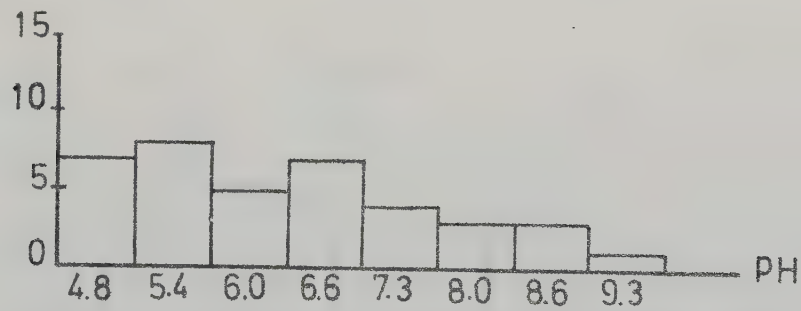
Tests on preference of different values of pH. Callicorixa producta.

The top figure and the staple diagram show the distribution of 100 specimens (10 tests) offered the possibility to chose among pH values of between 4.8 and 9.3.

Fig. 16.



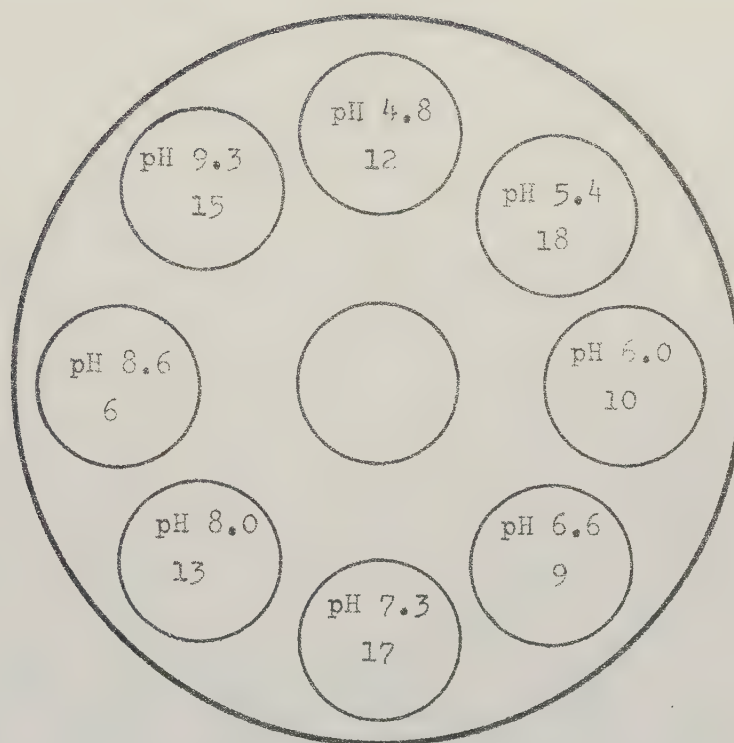
Number specimens.



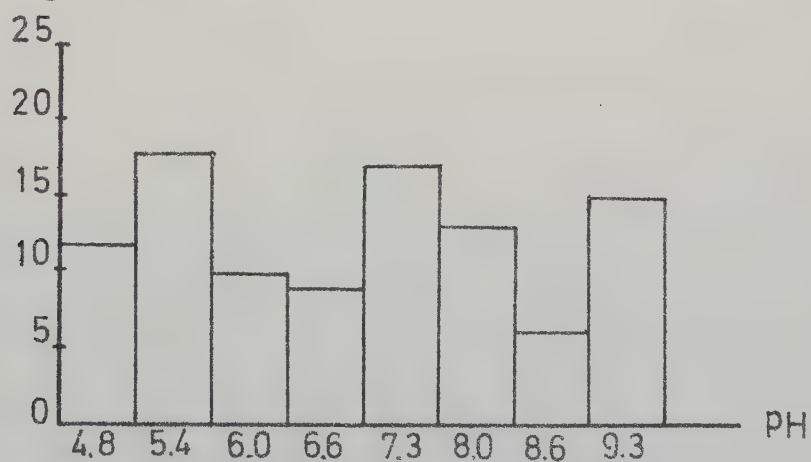
Tests on preference of different values of pH. Notonecta glauca.

The top figure and the staple diagram show the distribution of 38 specimens (4 tests) offered the possibility to chose among pH values of between 4.8 and 9.3.

Fig. 17.



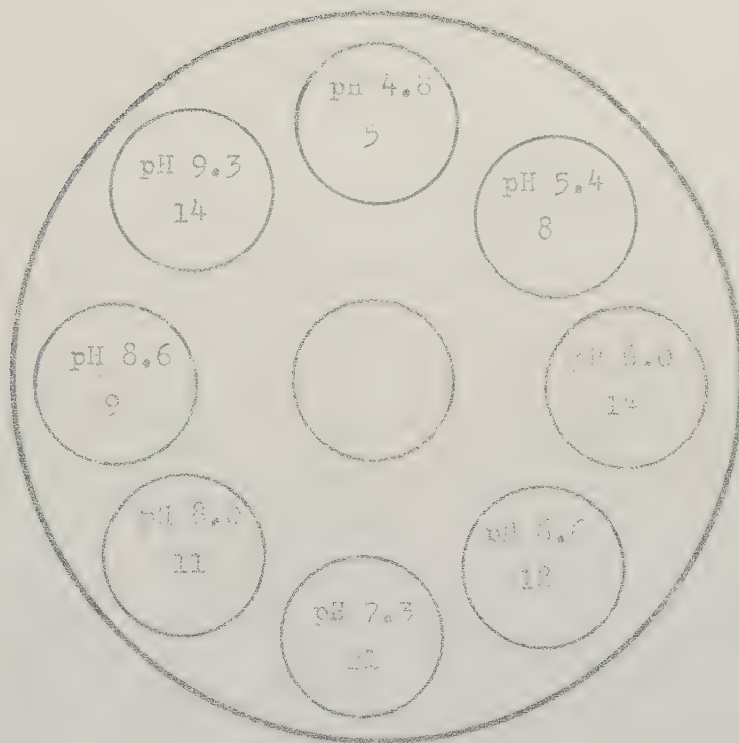
Number specimens.



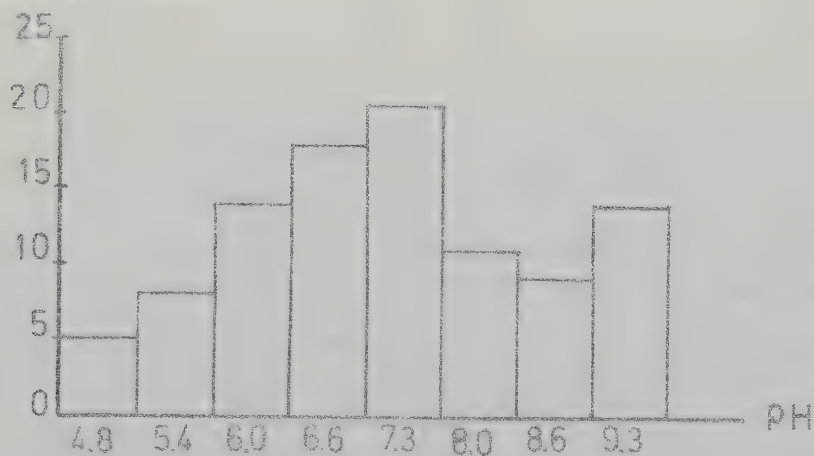
Tests on preference of different values of pH. Agabus bipustulatus.

The top figure and the staple diagram show the distribution of 100 specimens (10 tests) offered the possibility to chose among pH values of between 4.8 and 9.3.

1940, 1941



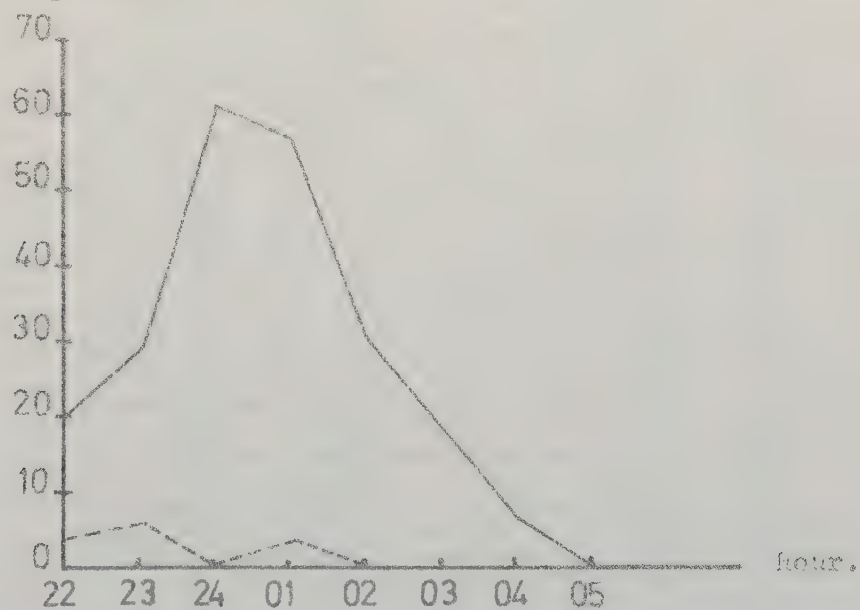
Number specimens.



Tests on preference of different values of pH. Coelambus parallelogramus.

The top figure and the staple diagram show the distribution of 100 specimens (10 tests) offered the possibility to chose among pH values of between 4.8 and 9.3.

Number specimens.



Number of Callicorixa producta caught in light trap
at two different types of weather. (See text, p. 47.)

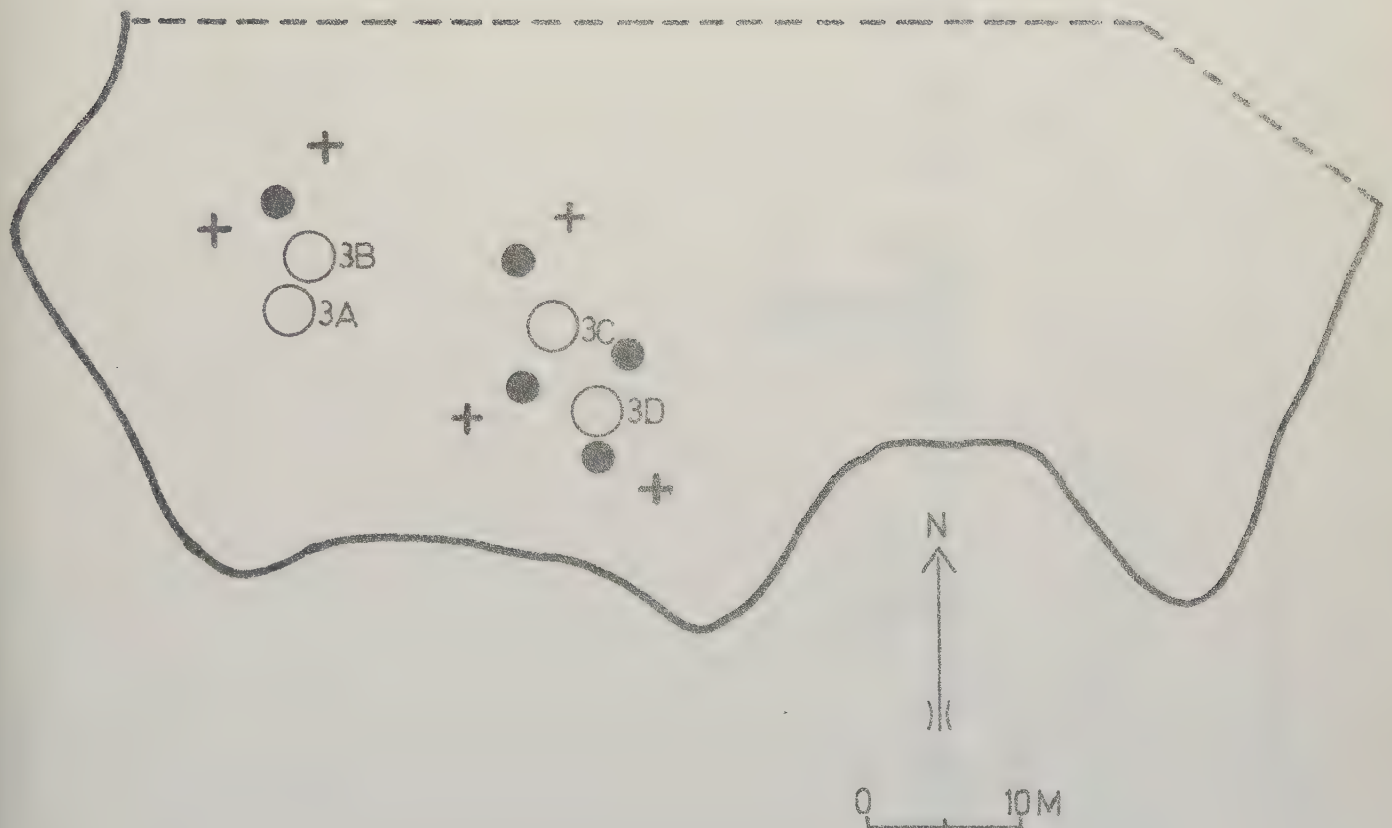
———— Type of weather: calm, cloudy, high R.H.,
high temperature.

- - - - - Type of weather: windy, fair, low R.H.,
low temperature.

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Air temp. °C	14.0	14.5	15.0	14.5	14.2	14.6	14.5	15.0	15.3	15.5	16.3	16.5	16.5	16.1	16.5	16.9	17.3	17.5	17.2	16.1	17.0	17.5	18.0	17.9	18.1	18.5	19.0	18.4	19.0	19.3
Water temp. 1 cm.	11.0	11.0	11.5	11.2	11.0	11.3	11.4	11.5	11.4	11.6	11.8	12.3	12.8	12.4	12.8	14.0	15.0	15.7	15.6	15.3	15.9	16.3	17.0	16.9	17.0	17.1	17.5	17.3	17.8	17.9
Water temp. 25 cm.	11.0	11.0	11.5	11.2	11.0	11.3	11.3	11.3	11.4	11.4	11.5	12.0	12.5	12.1	12.8	13.6	14.6	15.1	15.4	15.1	15.9	16.1	16.8	16.8	16.9	17.0	17.2	17.3	17.8	17.8
Wind m/s	4	4	5	0	2	4	1	0	4	1	1	1	3	0	6	1	2	0	2	2	4	1	1	3	2	3	1	5	6	2
Light cond.	(C)	(C)	(C)	S	S	C	S	S	S	(S)	S	S	(S)	C	(S)	S	S	S	(S)	S	C	(C)	S	(C)	(C)	(S)	S	C	(C)	S
Number specimens	50	46	44	48	44	46	23	46	48	43	45	42	45	21	40	45	40	41	36	30	32	27	20	22	16	18	15	15	13	14
% left of 50	92	92	88	96	88	92	46	92	96	86	90	84	90	42	80	90	80	82	72	60	64	54	40	44	32	36	30	30	26	28

Fig. 20. Table showing spring emigration in *Callicorixa producta* from one rock-pool in May, 1969. (See text, p. 49)
 S = no clouds, (S) = glimpses of sunshine, clouds, (C) = mainly overcast, glimpses of sunshine at times,
 C = entirely overcast.

Fig. 21.



Map of S.W. part of Sjöö showing the location of four permanent rock-pools of type 3 (open circles) and of ten small artificial pools arranged in two groups according to the distance from the original pools:

● = distance 0.3 - 3.0 m. from the original pools.

+ = distance 2.0 - 3.0 m. from the inner group of artificial pools.

Fig. 22.

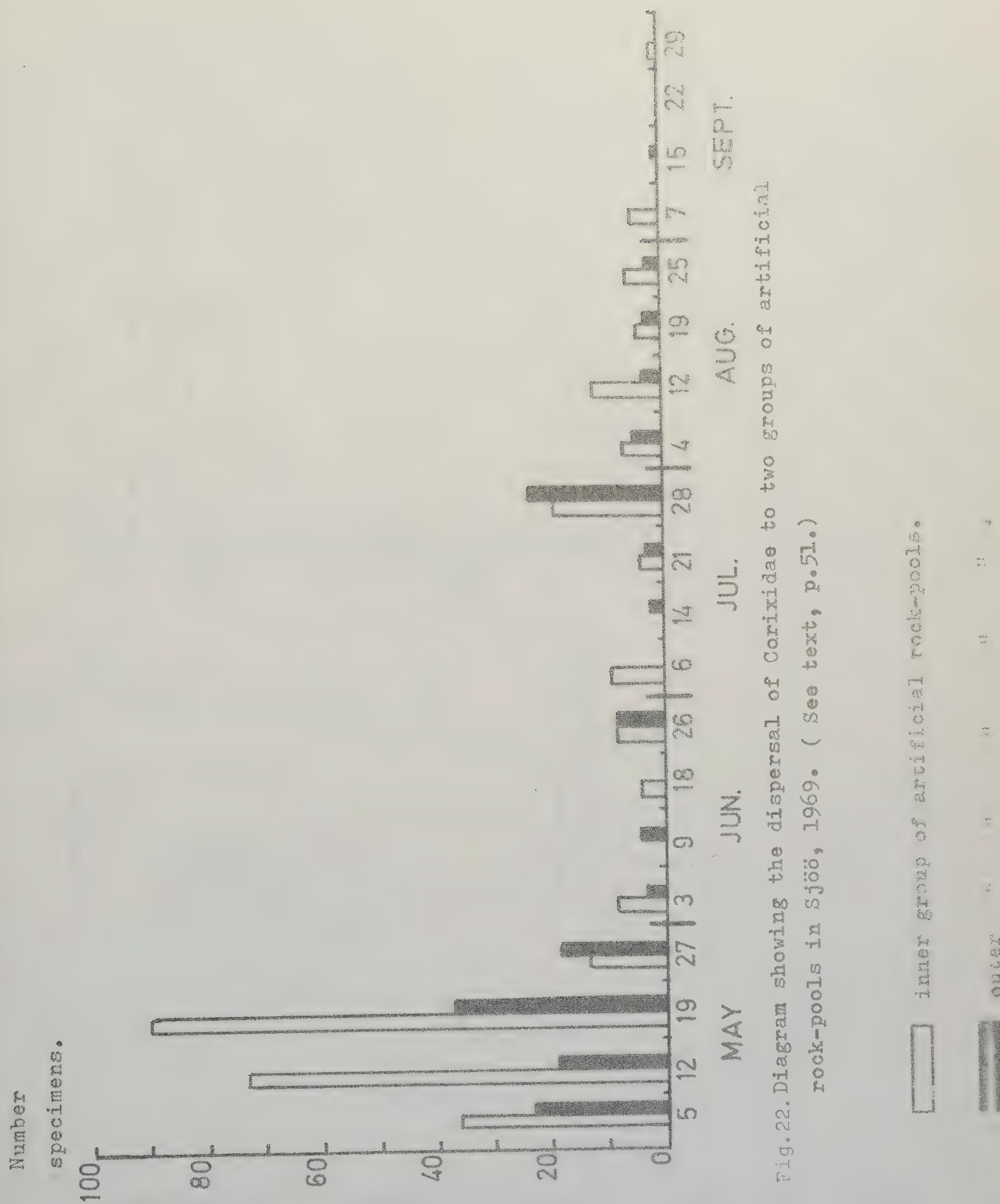
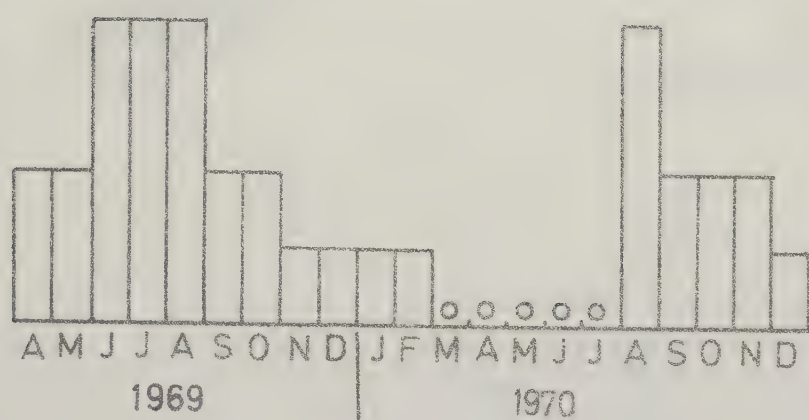
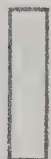


Fig.22. Diagram showing the dispersal of Corixidae to two groups of artificial rock-pools in Sjöö, 1969. (See text, p.51.)

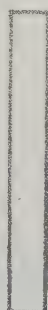
Fig. 23.



Single specimens.



Not common.



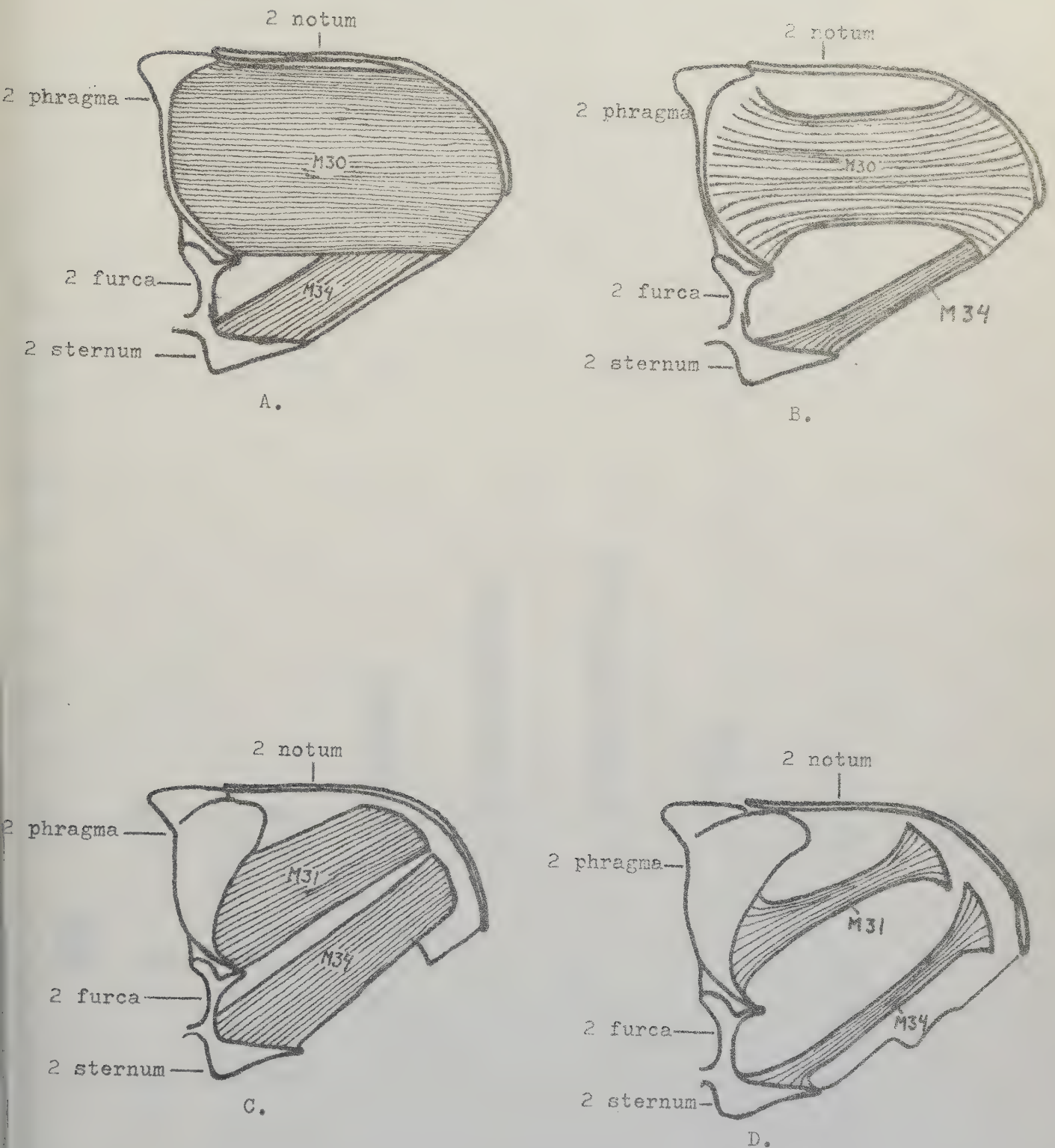
Common.



Looked for in vain.

The occurrence of *Callicorixa producta* in Sjöë 3C, 1969 to 1970.

Fig. 24.

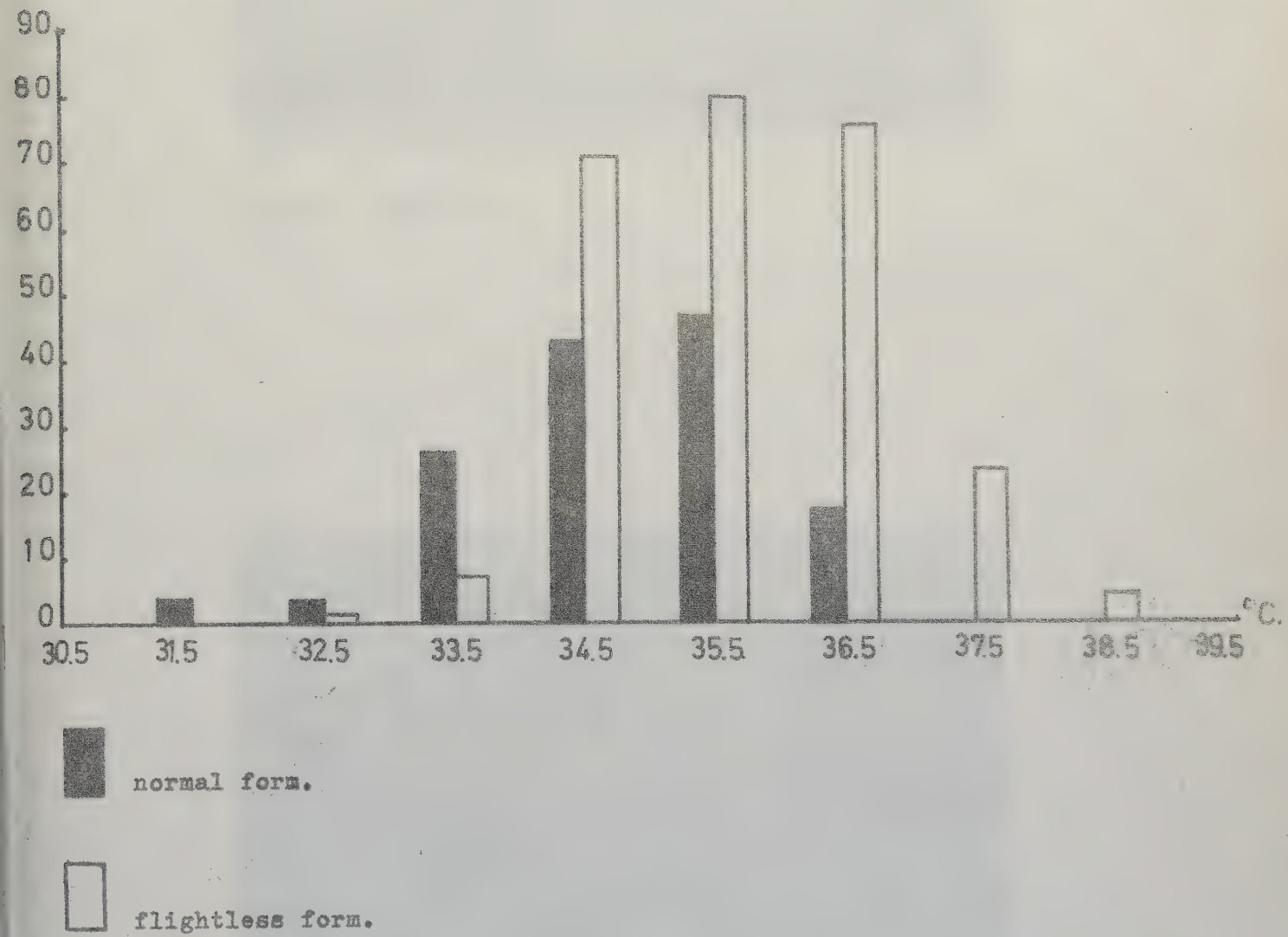


Main flight muscles of mesothorax in *Callicorixa producta*. (Somewhat generalized).

A. Normal form. B. Flightless form. C. Normal form. D. Flightless form.

(B-D from Young, 1965, slightly changed). (See text, p.58.)

Fig. 25.



Migrations of the two forms of Callicorixa producta at increased temperature.
(See text, p. 62.)



Fig.26. Sjöö 3A.



Fig.27. Sjöö 3B.



Fig.28. Sjöö 3C.



Fig.29. Sjöö 3D.



Fig.30. Tärnö 3A.



Fig.31. Bockö 3.



Fig.32. Sjöö 2A.



Fig.33. Sjöö 2B.



Fig.34. Tärnö 2A.



Fig.35. Tärnö 2B och 1A.



Fig.36. Bockö 2A.



Fig.37. Bockö 2B.



Fig.38. Harö 2.

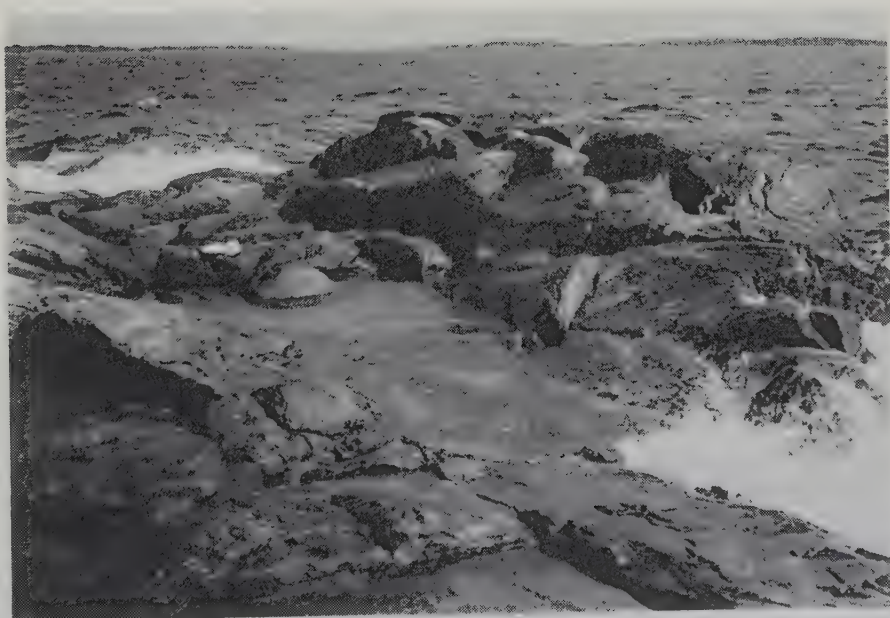


Fig.39. Sjöö 1A.

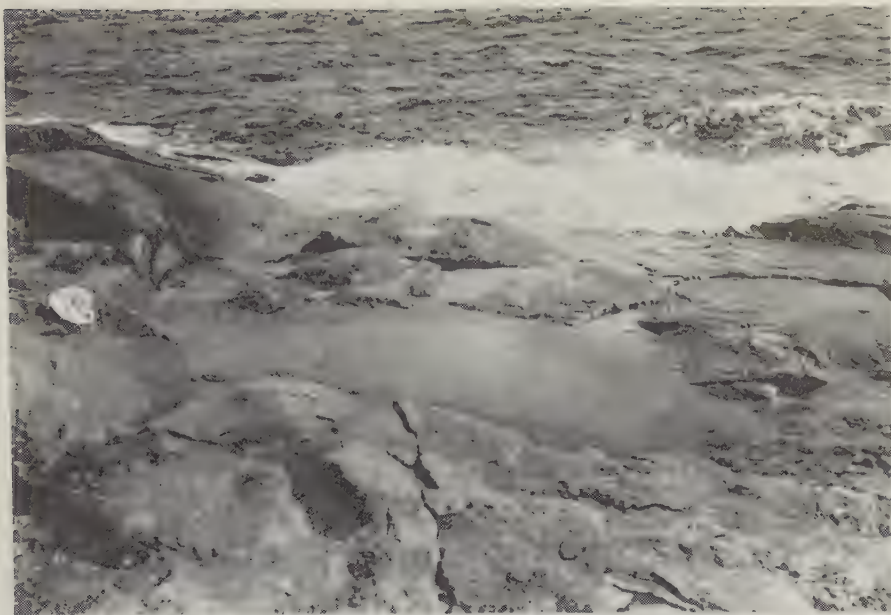


Fig.40. Sjöö 1B.



Fig.41. Sjöö 1C.



Fig.42. Tärnö 1B.



Fig.43. Bockö 1.

APPENDIX I.

Description of investigated rock-pools.

In the following description of the individual rock-pools the transparency has been estimated by means of a Secchi's disc according to which the following grouping has been used:

<u>Depth of visibility</u>				about 10 cm. - water turbid
"	"	"	"	20 cm. - water semi-transparent
"	"	"	"	30 cm. - water transparent

The water temperature is indicated without decimals and has been measured at the depth of 10 cm. between h 10 and 12.

Type 3.

Sjöö 3A. fig. 26.

Location: South-western part of the island, 20 m. from the shore. Altitude above sea level about 4 m.

Size: At the maximum about 2 x 3 m., at the minimum 0.5 x 3 m.

Depth: At a maximum 0.3 m., at a minimum 0.1 m.

Transparency: Water transparent.

Vegetation: Around the rock-pool sparse vegetation of lichens. In crevices Sedum acre. The rock-pool itself lacks vegetation except in the southern part where a carpet of Agrostis tenuis, often flooded, covers the ground. A thin layer of organic matter on the bottom of the pool.

Salinity: 0.3 - 4.0 per mille.

Sjöö 3B. fig. 27.

Location: This large rock-pool is situated in close vicinity to 3A. The two rock-pools are separated by a narrow rock threshold and in periods of rain they often communicate.

Size: About 5 x 5 m. Only insignificantly influenced by maximum and minimum water-level,

Depth: At the maximum 0.7 m., at the minimum 0.5 m.

Transparency: Water semi-transparent.

Vegetation: Somewhat richer than that of 3A but of the same type. A layer of organic matter up to 5 cm. thick covers the bottom.

Salinity: 0.3 - 0.7 per mille.

Sjöö 3C. fig. 28.

Location: Southern part of the island, 15 m. from the shore. Altitude above sea level about 3 m.

Size: About 5 x 5 m. On account of the steep margins of the rock-pool its surface is not very much influenced by the fluctuations of the level.

Depth: 1.5 - 1.7 m. The deepest of all investigated rock-pools.

Transparency: Water turbid.

Vegetation: Around the rock-pool: Sedum acre, Hypericum maculatum, Anthriscus silvestris, Angelica silvestris, and lichens. Lemna minor on the surface of the pool. The bottom is covered by a black layer of organic matter, in some places as thick as 10 cm.

Salinity: 0.5 - 0.7 per mille.

Sjöö 3D. fig. 29.

Location: Southern part of the island, 10 m. from the shore, 5 m. from 3C. Altitude about 3 m. above sea level.

Size: About 5 x 2 m. A rather constant size.

Depth: 0.7 - 0.8 m.

Transparency: Water turbid.

Vegetation: The surroundings have no vegetation. In the rock-pool a varying amount of Lemna minor. The bottom covered with black organic matter.

Salinity: 0.5 - 0.9 per mille.

Tärnö 3A. fig. 30.

Location: North-eastern part of the island, 20 m. from the shore. Altitude about 2 m. above sea level.

Size: At the maximum 7 x 4 m., at the minimum 5 x 2 m.

Depth: 0.3 - 0.5 m.

Transparency: Water transparent.

Vegetation: The rock-pool is situated in an area of bare rocks with no vegetation. The layer of organic matter on the bottom is thin.

Salinity: 0.1 - 0.7 per mille.

Triturus vulgaris occurs abundantly.

Tärnö 3B.

Location: North-eastern part of the island, 30 m. from the shore. Altitude about 2 m above sea level.

Size: At the maximum 6 x 4 m., at the minimum 5 x 3 m.

Depth: 0.4 - 0.6 m.

Transparency: Water semi-transparent.

Vegetation: Similar to that of Sjöö 3C. At the margins stands of Hypericum

maculatum, Anthriscus silvestris and Sedum acre. On the surface often Lemna minor. The layer of organic matter on the bottom black, up to 1 cm. About 20 m. away from the rock-pool pastures and groves begins, which distinguishes Tärnö and constitutes a result of earlier farming and grazing.

Salinity: 0.4 - 1.8 per mille.

Bockö 3. fig. 31.

Location: North-eastern point, 10 m. from the shore. Altitude about 5 m. above sea level.

Size: At the maximum 2 x 3 m. It may dry up entirely.

Depth: At the maximum 0.45 m.

Transparency: Water turbid.

Vegetation: The rock-pool is of the "Moostümpel" type (Lindberg, 1944) that is, the entire depression in which the rock-pool is formed has a carpet of moss, mainly Hypnum fluitans. Around the pool marshy vegetation of Carex species. Grazing cattle enrich the organic production in the area with their droppings. Characteristic of this rock-pool is that it easily dries up. The carpet of vegetation, however, keeps the bottom moist for which reason also aquatic species may possibly survive a dry period.

Salinity: 0.1 - 0.3 per mille.

Harö 3.

Location: North-western point, about 10 m. from the sea. Altitude 1.3 m. above sea level.

Size: At the maximum 2 x 4 m., at the minimum 1.5 x 3 m.

Depth: 0.4 - 0.5 m.

Transparency: Water semi-transparent.

Vegetation: The rock-pool is influenced by the same marshy meadow vegetation as Harö 2. At the margins stands of Triglochin palustre. The layer of organic matter is thin.

Salinity: 0.5 - 0.9 per mille.

Type 2.

Sjöö 2A. fig. 32.

Location: Southern part of the island, 5 m. from the shore. Altitude about 0.7 m. above sea level.

Size: At the maximum 2 x 2 m., at the minimum 1.5 x 1.5 m. (irregular form).

Depth: 0.2 - 0.5 m.

Transparency: Water semi-transparent.

Vegetation: Rock-pool and surroundings without vegetation.

Salinity: 0.4 - 8.2 per mille.

Sjöö 2B. fig. 33.

Location: Southern part of the island, 20 m. west of 2A. 10 m. from the shore. Altitude about 0.5 m. above sea level.

Size: At the maximum 2 x 4 m., at the minimum 1 x 3 m.

Transparency: Water transparent.

Vegetation: The rock-pool is without vegetation. In the neighbourhood, however, there is brush of Alnus glutinosa, in which also herbaceous plants grow. From this vegetation the winds often bring organic matter to the rock-pool, but this is almost lacking on the bottom because waves regularly wash the rock-pool clean.

Salinity: 0.4 - 10.0 per mille. The rock-pool after periods of rain receives considerable quantities of water from the vegetated ground mentioned above. On the other, strong waves from the south may fill the pool with sea water which after evaporation may cause high values of salinity. The measured value of 10 per mille is not necessarily the absolute maximum.

Tärnö 2A. fig. 34.

Location: North-eastern point, 12 m. from the shore, 20 m. from 3A. Altitude about 2 m. above sea level.

Size: About 1.5 x 4 m. As a consequence of the steep margins of the rock-pool, the size of its surface varies insignificantly.

Depth: 0.2 - 0.4 m.

Transparency: Water transparent.

Vegetation: No vegetation. On the bottom a thin layer of organic matter.

Salinity: 2.1 - 7.8 per mille.

Tärnö 2B. fig. 35.

Location: North-eastern point, 30 m. from 2A, 10 m. from the shore. Altitude about 0.5 m. above sea level.

Size: About 1.5 x 4 m, rather constant.

Depth: 0.25 - 0.45 m.

Transparency: Water transparent.

Vegetation: As in 2A.

Salinity: 3.3 - 8.6 per mille.

Bockö 2A. fig. 36.

Location: North-eastern point, 5 m. from the shore. Altitude about 1.7 m. above sea level.

Size: 0.5 x 3 m. The surface of a rather constant size.

Depth: 0.25 - 0.45 m.

Transparency: Water semi-transparent.

Vegetation: In the surroundings lichens. The rock-pool lacks lacks higher vegetations.

Salinity: 3.4 - 9.7 per mille.

Bockö 2B. fig. 37.

Location: North-eastern point, 10 m. from the sea. Altitude about 2 m. above sea level.

Size: At the maximum 1 x 3 m., at the minimum 0.5 x 2.5 m.

Depth: 0.1 - 0.3 m.

Transparency: Water semi-transparent.

Vegetation: The surroundings and the rock-pool without vegetation. On the bottom a thin layer of organic matter.

Salinity: 0.7 - 5.9 per mille.

Harö 2. fig. 38.

Location: The rock-pool is situated in a well sheltered bay at the north-western point of the island. Altitude 0.4 m. above sea level (normal water-level).

Size: At the maximum 3 x 6 m., at the minimum 2.5 x 5 m.

Depth: 0.3 - 0.4 m.

Transparency: Water transparent. (By the time of photographing the level of the sea was extremely high. In fact the rock-pool as a consequence of its sheltered location seldom receives any sea water).

Vegetation: The rock-pool is located in the centre of a rather wide depression in the bed-rock with vegetation of marshy meadow type, which is closely grazed by sheep and probably also by Branta canadensis which nests here. The bottom of the rock-pool lacks vegetation and consists of a stony bed of gravel with a very thin layer of organic matter.

Salinity: 2.1 - 7.2 per mille.

Mjöö 2.

Location: South-western point of the island, near a bay, opening towards the south-east. Distance to the shore about 8 m. Altitude 0.4 m. above sea level.

Size: At the maximum 2 x 3 m., at the minimum 1.7 x 3 m.

Depth: 0.5 - 0.6 m.

Transparency: Water semi-transparent.

Vegetation: Mjöo differs from all other investigated islands in consisting entirely of bare rocks so low that type 3 rock-pools are missing. The scanty vegetation is made up by lichens and by a few vascular plants, Isatis tinctoria, among others, growing in sheltered locations among boulders.

Salinity: 2.8 - 5.7 per mille.

(The island has been chosen as an area of investigation because of its lack of rock-pools of type 3. On islands where all three types are represented a dispersal of certain species from type three to type two and one can be expected.)

Type 1.

Sjöo 1A. fig. 39.

Location: South-western part of the island, very close to the sea. Already at a moderate force of wind, sea water washes into the pool and at high water it is transformed into a miniature bay.

Size: 2 x 4 m. The size of the surface remains rather constant at low sea-water level.

Depth: 0.6 - 0.8 m.

Transparency: Water transparent.

Vegetations: The immediate surroundings completely without vegetations. In the rock-pool: Fucus vesiculosus, Enteromorpha intestinalis, and Cladophora glomerata.

Salinity: 6.6 - 13.1 per mille.

(The fauna of this rock-pool is predominated by Gammarus locusta.)

Sjöo 1B. fig. 40.

Location: Southern part of the island, 3 m. from the shore. Altitude about 0.3 m. above sea level. The waves often dash into the rock-pool, but during the investigation period it never communicated directly with the sea. For this reason, the temperature is higher than in Sjöo 1A.

Size: At the maximum 3 x 4 m., at the minimum 1 x 2 m.

Depth: 0.1 x 0.4 m.

Vegetation: As in 1A. Layer of dead organic matter is missing, in its place there is a carpet of Enteromorpha intestinalis.

Salinity: 4.7 - 14.0 per mille.

Typical species of this rock-pool is Gammarus locusta.

Sjöö 1C. fig. 41.

Location: Southern part of the island, between 3D and the sea, about 5 m. from the shore. Altitude 0.3 m above sea level.

Size: At the maximum 4 x 4 m., at the minimum 1 x 2 m.

Depth: 0.2 - 0.5 m.

Transparency: Water transparent.

Vegetation: As in 1B.

Salinity: 3.3 - 9.0 per mille.

Tärnö 1A. fig 35.

Location: North-eastern point, between 2B and the shore, 4 m. from this. Altitude about 0.3 m. above sea level.

Size: At the maximum 1.5 x 4 m., at the minimum 0.7 x 3 m.

Depth: 0.15 - 0.4 m.

Transparency: Water transparent.

Vegetation: The surrounding without vegetations. In the rock-pool:

Fucus vesiculosus and Enteromorpha intestinalis.

Salinity: 3.9 - 14.3 per mille.

Gammarus locusta occurs abundantly.

Tärnö 1B. fig 42.

Location: North-eastern point, between 3A and the shore, 3 m from this.

Altitude about 0.5 m. above sea level.

Size: 1 x 3 m. Varies only slightly.

Depth: 0.25 - 0.45 m.

Transparency: Water transparent.

Vegetation: Surroundings without vegetation. In the rock-pool sparse Cladophora glomerata. Layer of organic matter thin. The rock-pool is intermediate between type 1 and 2 with respect to location, salinity, vegetation and fauna. As sea water already at moderate southern to south-eastern winds easily dashes into the pool it is here classified as type 1.

Salinity: 3.0 - 9.9 per mille.

Bockö 1. fig. 43.

Location: North-eastern part of the island. The rock-pool is closed off from the sea by a threshold, about 1 m. broad and 0.3 m. high.

Size: 1.5 x 2 m. The surface remains at a constant size due to sea water splashing into the pool.

Depth: 0.5 m.

Transparency: Water transparent.

Vegetation: The surrounding rocks are bare. In the rock-pool: Fucus vesiculosus, Enteromorpha intestinalis, and Cladophora rupestris. On the bottom a thin layer of organic matter in crevices.

Salinity: 6.3 - 9.3 per mille.

Gammarus locusta occurs in the pool.

Harö 1.

Location: North-western point of the island, 1 m. from the shore (normal water-level). Altitude 0.2 m. above sea level.

Size: At the maximum 2 x 2 m., at the minimum 1.5 x 2 m.

Depth: 0.4 - 0.5 m.

Transparency: Water transparent.

Vegetation: In the surroundings scanty vegetation of lichens. The rock-pool without vegetation. Layer of organic matter thin.

Salinity: 5.9 - 9.2 per mille.

Mjöö 1.

Location: South-western point of the bay (fig. 1), 10 m. from Mjöö 2, 1 m from the normal shore line. Altitude 0.2 m. above sea level.

Size: At the maximum 2 x 2 m., at the minimum 1.5 x 1.8 m.

Depth: 0.2 - 0.4 m.

Transparency: Water usually transparent but at times opaque from planktonic green algae.

Vegetation: The entire zone is without vegetation. Thin yellow layer of organic matter in the bottom crevices.

Salinity: 4.8 - 12.6 per mille.

APPENDIX II.

The distribution of insects in the investigated rock-pools.

Figures giving the abundance of the individual species at the date of observation:

1 = single specimens (often occasional).

2 = not common.

3 = common.

4 = mass occurrence.

In the tables, two groups have been distinguished. In the first are listed species and stages of development occurring in the rock-pool, in the second group those belonging to the bio-coenosis around the actual rock-pool (e.g. Diptera).

Table 1.

Sjöö 3A. 1964.

Date	19.4.	10.5.	30.5.	21.6.	4.7.	19.7.	15.8.	1.11.
Temp. +C ^o	8	14	22	19	19	20	18	13
<i>Callicorixa producta</i>	1	1	2	2	4	4	4	1
<i>Sigara semistriata</i>			1					
<i>Coelambus parallelogrammus</i>		2	3	3	3	1	1	1
<i>Agabus</i> sp. larvae								2
Chironomidae, larvae	1	2	3	3	4	3	3	3
<i>Ephydra alandica</i>						1		
<i>Scatella stagnalis</i>						1		

Table 2.

Sjöö 3A. 1965.

Date	15.4	8.5.	25.5.	19.6.	1.7.	10.7.	1.8.	3.11.
Temp. +C ^o	7	15	19	21	21	22	17	11
<i>Callicorixa producta</i>	1	1	2	3	3	2	2	1
<i>Coelambus parallelogrammus</i>		2	3					
Chironomidae, larvae	1	2	3	3	3	2	2	2
<i>Ephydra alandica</i>			1	1				

Table 3.

Sjöö 3A. 1966.

Date	16.4.	5.5.	20.5.	16.6.	3.7.	10.7.	5.8.	25.10.
Temp. +C°	9	16	20	22	23	22	21	15
<i>Callicorixa producta</i>	1	2	2	2	2	1	1	1
<i>Notonecta glauca</i> , adults					2	2	2	
<i>N. glauca</i> , larvae			2	2	2	1		
<i>Coelambus parallelogrammus</i>		2	3	1	2	1		
Chironomidae, larvae	2	3	3	2	2	2	2	2

Table 4.

Sjöö 3B. 1964.

Date	19.4.	10.5.	30.5.	21.6.	4.7.	10.7.	15.8.	1.11.
Temp. +C°	7	13	19	18	18	19	18	13
<i>Callicorixa producta</i>		1	1	3	3	3	3	1
<i>C. praeusta</i>		1	1	1				
Chironomidae, larvae	2	2	3	4	4	4	4	3
<i>Agabus</i> sp. larvae								1
<i>Ephydra alandica</i>				1				
<i>Coenia palustris</i>					1			
<i>Notiphila cinerea</i>					2			
<i>Dolichopus plumipes</i>					1			
<i>Campsicnemus scambus</i>					1			
<i>Themira putris</i>					1			

Table 5.

Sjöö 3B. 1965.

Date	15.4.	8.5.	25.5.	19.6.	1.7.	10.7.	1.8.	3.11.
Temp. +C°	7	14	18	20	21	21	17	11
<i>Callicorixa producta</i>		2	2	3	2	2	2	1
<i>C. praeusta</i>		1	1					
<i>Ephydra</i> sp. pupae					1			
Chironomidae, larvae	2	2	3	3	2	2	2	2
<i>Ephydra alandica</i>			1			1		
<i>Coenia palustris</i>					1	1		
<i>Notiphila cinerea</i>						1		
<i>Campsicnemus scamus</i>					1			

Table 6.

Sjöö 3B. 1966.

Date	16.4.	5.5.	20.5.	16.6.	3.7.	10.7.	5.8.	25.10.
Temp. +C°	8	15	20	21	22	21	21	15
<i>Callicorixa producta</i>	1	2	3	2	2	2	2	2
<i>Notonecta glauca</i> , adults				1	2			
<i>N. glauca</i> , larvae			2	2	1			
Chironomidae, larvae	2	3	3	3	2	2	2	
<i>Ephydra alandica</i>				2	2	2		
<i>Dolichopus plumipes</i>					1			

Table 7.

Sjöö 3C. 1964.

Date	19.4.	10.5.	19.5.	30.5.	21.6.	4.7.	10.7.	15.8.	1.11.
Temp. +C ^o	7	14	19	19	18	18	19	19	14
<i>Callicorixa producta</i>					1	2	1	1	1
<i>Agabus bipustulatus</i>						1	1	1	1
<i>A. sp. larvae</i>									1
<i>Chaoborus</i> , larvae	2	4	4	4	4	4	4	3	1
<i>Chaoborus</i> (hatching)		3	2	1					
Chironomidae, larvae	3	3	3	3	3	3	3	3	3
Chironomidae (hatching)			3	2					

Table 8.

Sjöö 3C. 1965.

Date	15.4.	8.5.	25.5.	19.6.	1.7.	10.7.	1.8.	3.11.
Temp. +C ^o	7	14	18	20	21	21	17	11
<i>Callicorixa producta</i>	1	1	2	2	2	2	2	1
<i>Notonecta glauca</i> , larvae			2	2	2	1		
<i>N. glauca</i> , adults				1	2	2	2	
<i>Chaoborus</i> , larvae	2	3	4	4	4	3	2	
Chironomidae, larvae	3	3	3	3	3	2	2	2

Sjöö 30. 1966.

Date	16.4.	5.5.	20.5.	16.6.	3.7.	10.7.	5.8.	25.10.
Temp. +C ^o	8	15	20	21	22	21	21	15
Callicorixa producta		2	2	3	2	2	2	2
Notonecta glauca, larvae			3	3	2	1		
N. glauca, adults			1	2	2	2	2	2
Chironomidae, larvae	2	2	3	3	2	2	2	2

Sjöö 3D. 1964.

[illegible]

Table 11.

Sjöö 3D. 1965.

Date	15.4.	8.5.	25.5.	19.6.	1.7.	10.7.	1.8.	3.11.
Temp. +C ⁰	7	14	18	20	21	21	17	11
<i>Callicorixa producta</i>	2	2	3	4	4	4	4	2
<i>Sigara nigrolineata</i>								1
<i>Hesperocorixa sahlbergi</i>			1					
<i>Agabus bipustulatus</i>							2	2
<i>A. sp. larvae</i>								2
Chironomidae, larvae	1	2	2	2	2	2	2	1

Table 12.

Sjöö 3D. 1966.

Date	16.4	5.5.	20.5.	16.6.	3.7.	10.7.	5.8.	25.10.
Temp. +C ⁰	8	15	20	21	22	21	21	15
<i>Callicorixa producta</i>			1	2	2	2	2	2
<i>Hesperocorixa sahlbergi</i>					1			
<i>Gyrinus substriatus</i>				2	2		1	
<i>Agabus bipustulatus</i>							1	1
Chironomidae, larvae	1	1	2	1	1	1	1	

Table 13.

Tärnö 3A. 1964

Date	19.4.	19.5.	22.6	7.7.	15.7.	2.8.	19.8.	5.9.	1.11.
Temp. +C°	11	18	18	16	20	22	18	17	9
<i>Callicorixa producta</i>			1	2	2	2	2	2	1
<i>C. prod.</i> 1 st instar			1						
<i>Saldula saltatoria</i>						1			
<i>Gerris odontogaster</i> , macropterous			1	1	2	3	1		
<i>Gerris odontogaster</i> , brachypterous						2	2		
<i>Gerris odontogaster</i> , larvae						3			
<i>Gerris thoracicus</i> macropterous						1			
Chironomidae, larvae			1	1	1	1			
<i>Scatella stagnalis</i>		1	1	2	2	2	1	1	
<i>S. paludum</i>			1	1	1	1			
<i>Hydrellia ranunculi</i>						1			

Table 14.

Tärnö 3A. 1965.

Date	23.4.	15.5.	20.6.	15.7.	22.7.	2.8.	15.8.	1.9.	15.9.	25.10
Temp. +C°	12	16	17	22	21	21	19	17	15	10
<i>Callicorixa producta</i>	1	1	2	3	2	2	2	2	2	1
<i>Gerris odontogaster</i> , macropterous					2	1	1			
<i>G. odontogaster</i> , brachypterous			2	3	3	3	2			
<i>G. odontogaster</i> , larvae			2	3	2	2				
Chironomidae, larvae			2	2	1	1				
<i>Scatella stagnalis</i>		1	1	2	2	2	1	1	1	
<i>S. paludum</i>			1	1	1					

Table 15.

Tärnö 3A. 1966.

Date	20.4.	15.5.	18.6.	10.7.	25.7.	5.8.	13.8.	3.9.	17.9.	3.11.
Temp. +C°	13	16	17	18	23	21	20	18	16	8
<i>Callicorixa producta</i>	1	2	2	3	3	2	2	1	1	1
<i>Gerris odontogaster</i> , macropterous				1	2					
<i>G. odontogaster</i> , brachypterous			3	3	3	2	1			
<i>G. odontogaster</i> , larvae				3	3	2				
Chironomidae, larvae			2	2	1					
<i>Scatella stagnalis</i>		1	2	2	1	3	2	2		
<i>S. paludum</i>			2	1						

Table 16.

Tärnö 3B. 1964.

Date	19.4.	19.5.	22.6.	7.7.	15.7.	2.8.	19.8.	5.9.	1.11.
Temp. +C°	11	18	18	16	20	22	22	17	9
<i>Callicorixa producta</i>	1	2	2	2	3	3	3	3	2
<i>C. prod.</i> 1 st instar		2	2						
Chironomidae, larvae	1	2	3	3	3	3	2	2	2
Chironomidae, (hatching)		2	3						
<i>Scatella stagnalis</i>		2	1	2		2	2	1	
<i>S. paludum</i>				1		2	2	1	

Table 17.

Tärnö 3B. 1965.

Date	23.4.	15.5.	20.6.	15.7.	22.7.	2.8.	15.8.	1.9.	15.9.	25.10.
Temp. +C ^o	11	15	17	22	20	21	19	17	15	10
Callicorixa producta	1	2	2	3	3	3	3	2	2	2
Chironomidae, larvae		1	1	2	2	2	2	2	2	1
Scatella stagnalis		2		1	2	2		1	1	
S. paludum				1	2			1		
Paratanytarsus natvigi				1			1			

Table 18.

Tärnö 3B. 1966.

Date	20.4.	15.5.	18.6.	10.7.	25.7.	5.8.	13.8.	3.9.	17.9.	3.11.
Temp. +C ^o	13	16	17	18	23	21	20	18	16	8
Callicorixa producta		1	2	2	2	3	3	2	2	1
Hydroporus erythrocephalus							1	1		
Chironomidae, larvae	1	1	2	2	2	2	2	2	2	1
Scatella stagnalis		2	1							
S. paludum				1	1					
Psectrocladius cf. limbatellus						1				

Table 19.

Bockö 3. 1964.

Date.	20.5.	10.6.	27.6.	5.7.	15.7.	After 15.7. the rock-pool was dried up for the rest of the season.
Temp. +C ^o	18	18	23	27	27	
<i>Callicorixa producta</i>	2	3	3	2	2	
<i>C. prod.</i> larvae 1 st instar	2					
<i>Hydroporus erythrocephalus</i>				1		
Chironomidae, larvae	1	1	1			
<i>Hydrobius fuscipes</i>				1		
<i>Scatella stagnalis</i>	2	2	2		1	
<i>S. paludum</i>			1	1	1	
<i>Notiphila cinerea</i>					1	
<i>Hydrellia griseola</i>			1	1		
<i>Themira putris</i>				1		

Table 20.

Bockö 3. 1965.

Date	15.5.	17.6.	1.7.	15.7.	21.7.		17.9.
Temp. +C ^o	17	20	21	22	21		16
<i>Callicorixa producta</i>	2	2	2	1		dried up	2
<i>Hydroporus erythrocephalus</i>		1	1	1		20.7. - 5.9.	1
<i>Hydrobius fuscipes</i>			2	1	1		
Chironomidae, larvae	2	2	2	1	1		
<i>Scatella stagnalis</i>	3	1	2				
<i>S. paludum</i>		1	1				
<i>Notiphila cinerea</i>			2		1		
<i>N. uliginosa</i>		1					
<i>Hydrellia griseola</i>				2			

Table 21.

Bockö 3. 1966.

Date	20.4.	15.5.	18.6.	27.6.		17.9.
Temp. +C°	14	17	20	23		16
<i>Callicorixa producta</i>	2	3	3	3	dried up	1
<i>Hydroporus erythrocephalus</i>		2	1	1	30.6. - 1.9.	1
Chironomidae, larvae		2	2	1		
<i>Scatella stagnalis</i>		2	1	2		
<i>Notiphila uliginosa</i>			2	1		

Table 22.

Harö 3. 1964

Date	20.5.	10.6.	25.6.	9.7.	15.7.	1.8.	14.8.	5.9.	11.10.
Temp. +C°	18	19	23	26	24	21	20	20	16
<i>Callicorixa producta</i>	3	4	4	4	4	4	3	3	3
<i>C. prod.</i> larvae	3	2	1						
<i>Gerris lacustris</i>						2	1		
<i>Agabus bipustulatus</i>	1			1	2		1		2
<i>Coelambus parallelogrammus</i>	1	2	1	2	2	2	2	1	1
<i>Helophorus</i> sp.			2	1					
Tricoptera sp. larvae							1		
<i>Hydroporus erythrocephalus</i>				1	2	1	1		
Chironomidae, larvae	3	3	3	3	3	2	2	2	2
Chironomidae, (hatching)	2	2	1	1					
<i>Scatella stagnalis</i>	1	1	3	2	1	2	2		
<i>Notiphila cinerea</i>			1	1					
<i>N. uliginosa</i>			1						
<i>Hydrellia chrysostoma</i>			2						
<i>H. griseola</i>			2	1					
<i>Syntormon rufipes</i>				1	1				
<i>Campsicnemus armatus</i>			1	2					
<i>Cetema elongata</i>				1	1				
<i>Collinellula lutea</i>				2					

Table 23.

Harö 3. 1965.

Date	15.5.	17.6.	1.7.	15.7.	21.7.	6.8.	24.8.	17.9.
Temp. +C°	17	19	20	20	21	18	15	15
<i>Callicorixa producta</i>	2	3	3	3	4	4	3	2
<i>Gerris lacustris</i>					2	1	1	
<i>G. rufoscutellatus</i>				1				
<i>Agabus bipustulatus</i>		1	2	2	2	2	1	1
<i>Coelambus parallelogrammus</i>	2	2	1	1	1	1	1	1
<i>Hydroporus erythrocephalus</i>			2	2	2	1		
Chironomidae, larvae	2	2	3	2	2	1	1	1
<i>Scatella stagnalis</i>	1	2	1	2	4	2		
<i>Notiphila cinerea</i>		2	1					
<i>Hydrellia chrysostoma</i>			1		1			
<i>H. griseola</i>				1				
<i>Campsicnemus armatus</i>			2	2				

Table 24.

Harö 3. 1966

Date	15.5.	18.6.	28.6.	10.7.	27.7.	10.8.	27.8.	16.9.
Temp. +C°	17	19	22	22	21	20	17	15
<i>Callicorixa producta</i>	2	2	1	1		1	2	2
<i>Agabus bipustulatus</i>		2	2					
<i>Coelambus parallelogrammus</i>	1	1	2				1	1
Chironomidae, larvae	2	3	3	1				
<i>Scatella stagnalis</i>	1	3	3	1				
<i>Notiphila cinerea</i>			1					
<i>Glyptotendipes barbipes</i>				1				
<i>G. paripes</i>				1	1			
<i>Psectrocladius cf. limbatellus</i>						2		

Table 25.

Sjöö 2A. 1964.

Date	19.4.	9.5.	20.6.	29.6.	1.7.	12.7.	18.7.	15.8.	5.9.	1.11.
Temp. +C°	10	22	22	16	18	16	22	20	20	11
<i>Callicorixa producta</i>		1				1			1	
<i>C. prod.</i> larvae 1 st instar			1							
<i>Gerris rufoscutellatus</i>	1									
<i>Ephydra</i> sp. pupae					1	3	3			
Chironomidae, (hatching)		3	2							
Chironomidae, larvae		2	3	3	3	3	3	3	3	1
Chironomidae, pupae		3	2	1						
<i>Saldula saltatoria</i>			1							
<i>Chiloxanthus pilosus</i>			1							
<i>Ephydra riparia</i>	1				1					
<i>E. alandica</i>	1	1	1	1	2	2	3	3	2	1
<i>Scatella stagnalis</i>			1	1	2	1	1	1	1	
<i>S. paludum</i>				1	3	2	2	2	2	
<i>Coenia fumosa</i>					1					
<i>Hilara monedula</i>				1						
<i>Hydrophorus praecox</i>			2	1	1	1				
<i>Heterochila buccata</i>										1
<i>Coelopa frigida</i>			1							
<i>C. pilipes</i>						1				

Table 26.

Sjöö 2A. 1965

Date	15.4.	8.5.	25.5.	19.6.	1.7.	10.7.	1.8.	3.10.
Temp. +C ^o	8	16	20	21	22	22	17	11
<i>Callicorixa producta</i>		1	2	1			1	
<i>Ephydra</i> sp. pupae					2	3		
Chironomidae, larvae	1	2	3	3	2	2	2	1
<i>Ephydra riparia</i>					1	1		
<i>E. alandica</i>		1	1	1	2	3	3	
<i>Scatella stagnalis</i>			1	1	2	2		
<i>S. paludum</i>				2	2	3		
<i>Hydrophorus praecox</i>				2	1			

Table 27.

Sjöö 2A. 1966

Date	16.4.	5.5.	20.5.	16.6.	3.7.	10.7.	5.8.	25.10.
Temp. +C ^o	9	16	21	22	23	22	21	15
<i>Callicorixa producta</i>	1	1	2	1				2
<i>Ephydra</i> sp. pupae					3	3	2	
Chironomidae, larvae		2	2	2	2	1	1	2
<i>Ephydra riparia</i>			1		1	1		
<i>E. alandica</i>				2	3	3		
<i>Scatella stagnalis</i>			1	2	2			
<i>S. paludum</i>					2			

Table 28.

Sjöö 2B. 1964

Date	19.4.	19.5.	20.6.	29.6.	1.7.	12.7.	18.7.	15.8.	5.9.	1.11.
Temp. +C°	10	22	23	18	20	18	28	20	19	11
<i>Callicorixa producta</i>		2	1						1	2
<i>Helophorus</i> sp.						1	2			
<i>Coelambus parallelogrammus</i>	1	1						1	1	
<i>Agabus bipustulatus</i>										2
<i>Agabus</i> sp. larvae	1	2						1		
Chironomidae: hatching		2	1							
Chironomidae: larvae	1	2	1	1	1	1	1	1		
Chironomidae: pupae		2	1							
<i>Ephydra alandica</i>		1	1	1	1	2	2			
<i>Scatella stagnalis</i>				1	2	2	1	1		
<i>S. paludum</i>					1	1	3			
<i>Hydrellia ranunculi</i>							1			
<i>Hercostomus metallicus</i>				1	1	3	3			
<i>Dolichopus plumipes</i>					1					
<i>Hydrophorus praecox</i>					1					

Table 29.

Sjöö 2B. 1965.

Date	15.4.	8.5.	25.5.	19.6.	1.7.	10.7.	1.8.	3.11.
Temp. +C°	8	16	20	21	22	22	17	11
<i>Callicorixa producta</i>		1	2	1			1	1
<i>Coelambus parallelogrammus</i>	1	1					2	
<i>Agabus bipustulatus</i>							1	1
Chironomidae, larvae	2	2	1	1	1	1	1	1
<i>Ephydra alandica</i>		1	2	2		2		
<i>Scatella stagnalis</i>			2	2	1	2		
<i>S. paludum</i>					3	2	1	
<i>Hercostomus metallicus</i>				2	2	1		
<i>Hydrophorus praecox</i>				1		2		

Table 30.

Sjöö 2B. 1966.

Date	16.4.	5.5.	20.5.	16.6.	3.7.	10.7.	5.8.	25.10.
Temp. +C°	9	16	21	22	23	22	21	15
<i>Callicorixa producta</i>	1	2			1		2	
<i>Coelambus parallelogrammus</i>							2	
<i>Agabus bipustulatus</i>							1	
Chironomidae, larvae	1	2	1	1				
<i>Ephydra alandica</i>			1	2	2			
<i>E. riparia</i>			1					
<i>Scatella stagnalis</i>				2	2			
<i>S. paludum</i>				1	2	2		

Table 31.

Tärnö 2A. 1964.

Date	19.4.	19.5.	22.6.	7.7.	2.8.	19.8.	5.9.	1.11.
Temp. +C ^o	11	18	22	16	21	23	19	9
<i>Callicorixa producta</i>		1	1	1	1	1	1	
<i>C. producta</i> , larvae 1 st instar			2					
<i>Gerris odontogaster</i> , macropterous					1	1		
<i>Helophorus</i> sp.				2				
Chironomidae, larvae			1	1	1			
Chironomidae, (hatching)			1					

Table 32.

Tärnö 2A. 1965.

Date	23.4.	15.5.	20.6.	15.7.	22.7.	2.8.	15.8.	1.9.	15.9.	25.10.
Temp. +C ^o	12	16	17	22	21	21	19	17	15	10
<i>Callicorixa producta</i>		1		2	1	1	1	1		
<i>Gerris odontogaster</i> macropterous						2	1			

Table 33.

Tärnö 2A. 1966.

Date	20.4.	15.5.	18.6.	10.7.	25.7.	5.8.	13.8.	3.9.	17.9.	3.11.
Temp. +C ^o	13	16	17	18	23	21	20	17	16	8
<i>Callicorixa producta</i>	1	2	2	2	2	2	1	1	1	
<i>Gerris odontogaster</i> macropterous					1	3	1			

Table 34.

Tärnö 2B. 1964.

Date	19.4.	19.5.	22.6.	7.7.	15.7.	2.8.	19.8.	5.9.	1.11.
Temp. +C ⁰	11	18	22	16	20	23	19	17	9
<i>Callicorixa producta</i>		1					1		
<i>C. prod.</i> 1 st instar		1							
<i>Gerris odontogaster</i> macropteros							1		
<i>Helophorus</i> sp.				1	1	1			
Chironomidae, larvae		2	2	2	2	1	2	1	1
Chironomidae, (hatching)			2	1					
<i>Ephydra riparia</i>					1				

Table 35.

Tärnö 2B. 1965.

Date	23.4.	15.5.	20.6.	15.7.	22.7.	2.8.	15.8.	1.9.	15.9.	25.10.
Temp. +C ⁰	12	16	17	22	21	21	19	17	15	10
<i>Callicorixa producta</i>			2	2	2	2	2	1		
<i>Gerris odontogaster</i> macropteros						1	1			

Table 36.

Tärnö 2B. 1966.

Date	20.4.	15.5.	18.6.	10.7.	25.7.	5.8.	13.8.	3.9.	17.9.	3.11.
Temp. +C ⁰	13	16	17	18	23	21	20	17	16	8
<i>Callicorixa producta</i>		2					1			
<i>Gerris odontogaster</i> macropteros							2			

Table 37.

Bockö 2A. 1964.

Date	20.5.	10.6.	27.6.	5.7.	15.7.	3.8.	15.8.	5.9.
Temp. +C°	19	20	28	28,5	28	23	22	21
Ephydra sp. pupae				1	1	1		
Chironomidae, larvae	1	2	1	1		1		
Chironomidae, (hatching)	1	1						
Scatella stagnalis		2	2	1	2	1	1	
S. paludum				1	1			
Ephydra alandica		1	1	2	3	1	1	1
Hydrophorus praecox				2	1	1		

Table 38.

Bockö 2A. 1965.

Date	15.5.	17.6.	1.7.	15.7.	21.7.	5.8.	25.8.	17.9.
Temp. +C°	17	20	20	21	21	19	16	16
Hydroporus erythrocephalus					1			
Ephydra sp. pupae			1	2	2			
Chironomidae, larvae	1	2	2	1				
Hydrophorus praecox					2	2	2	1
Ephydra alandica		2	2	3	2	1		
Scatella stagnalis	1	2	2	3	2	1		
S. paludum		1	2					

Table 39.

Bockö 2A. 1966.

Date	20.4.	15.5.	18.6.	27.6.	10.7.	25.7.	8.8.	28.8.	17.9.
Temp. +C°	14	17	20	23	23	22	20	17	16
<i>Hydroporus erythrocephalus</i>						2	1	1	
<i>Ephydra</i> sp. pupae					2				
Chironomidae, larvae	1	1	2	2	2	2	1		1
<i>Hydrophorus praecox</i>				1	2	2	1	1	
<i>Ephydra alandica</i>		2	1	1			1		
<i>Scatella stagnalis</i>		2	2	2					

Table 40.

Bockö 2B. 1964.

Date	20.5.	10.6.	27.6.	5.7.	15.7.	3.8.	15.8.	5.9.
Temp. +C°	19	20	28	28	28	23	22	21
<i>Callicorixa producta</i>	3	4	4	4	4	3	4	3
<i>Helophorus</i> sp.				2				
Chironomidae, larvae	1	3	3	3	3	2	2	1
<i>Scatella stagnalis</i>	1	2	1	2	2	1	1	
<i>S. paludum</i>		2	3	1	2			
<i>Hydrellia griseola</i>					2	1		

Table 41.

Bockö 2B. 1965.

Date.	15.5.	17.6.	1.7.	15.7.	21.7.	5.8.	25.8.	17.9.
Temp. +C ^o	17	20	20	21	21	19	15	16
<i>Callicorixa producta</i>	2	2	3	3	2	2	2	1
<i>Chironomidae</i> , larvae	2	2	1	1	1	1	1	
<i>Scatella stagnalis</i>		2	3	3	2		1	
<i>S. paludum</i>		2		2	2			

Table 42.

Bockö 2B. 1966

Date	20.4.	15.5.	18.6.	27.6.	10.7.	25.7.	8.8.	28.8.	17.9.
Temp. +C ^o	14	17	20	23	23	22	20	17	16
<i>Callicorixa producta</i>	1	2	3	2			1	1	1
<i>Hydroporus erythrocephalus</i>				1	1				
<i>Chironomidae</i> , larvae	1	2	3	2	2	1	1		
<i>Ephydra alandica</i>			2	2		2			
<i>Scatella stagnalis</i>		2	2	3	2	1	2		
<i>S. paludum</i>			1	1	2				

Table 43.

Harö 2. 1964.

Date	20.5.	10.6.	25.6.	9.7.	15.7.	1.8.	14.8.	5.9.	11.10.
Temp. +C°	19	19	23	27	24	22	20	20	16
<i>Callicorixa producta</i>	2	2	3	2	2				1
<i>Gerris lacustris</i>						1	1		
<i>Coelambus parallelogrammus</i>	1	1	2	2	3	2	1	1	1
<i>Hydroporus erythrocephalus</i>			1						
<i>Agabus bipustulatus</i>					1				
<i>Helophorus</i> sp.			1	1					
Chironomidae, larvae	3	3	2	2	3	3	2	2	2
Chironomidae, (hatching)	2	2	1						
<i>Saldula pilosella</i>							1		
<i>Ephydra alandica</i>			1	2	1	2	1		
<i>Scatella stagnalis</i>		2	4	2	2	2	1	2	1
<i>Coenosia pumila</i>				1	1				
<i>Hydroporus praecox</i>			2	2	1	2			
<i>Schoenomyza litorella</i>				1	1				

Table 44.

Harö 2. 1965

Date	15.5.	17.6.	1.7.	15.7.	21.7.	6.8.	24.8.	17.9.
Temp. +C°	17	19	20	21	22	18	15	15
<i>Callicorixa producta</i>	1	1	2	2	2	2	2	1
<i>Gerris lacustris</i>			1	1				
<i>Notonecta glauca</i> , larvae	1	2	1					
<i>Notonecta glauca</i> , adults		1	2	2	2	1	1	
<i>Coelambus parallelogrammus</i>	1	2	1	1				
Chironomidae, larvae	2	3	2	2	2	1	1	1
<i>Ephydra alandica</i>		2	2	2		1	1	
<i>Scatella stagnalis</i>	1	2	3		2	1	2	1
<i>Hydroporus praecox</i>			1	2	1			

Table 45.

Harö 2. 1966

Date	15.5.	18.6.	28.6.	10.7.	27.7.	15.8.	27.8.	16.9.
Temp. +C°	17	19	22	23	22	20	17	15
<i>Callicorixa producta</i>	2	3	2	1	1	1	1	1
<i>Notonecta glauca</i> , larvae	1	2	2	1				
<i>Notonecta glauca</i> , adults	1	2	2	2	3	2		
<i>Coelambus parallelogrammus</i>		1	1					
<i>Agabus bipustulatus</i>				1				
Chironomidae, larvae	2	3	3	2	2	2	1	1
<i>Ephydra alandica</i>		2	2		1	1		
<i>Scatella stagnalis</i>	2	2	3	3	2	3	2	2
<i>Syntormon rufipes</i>			1		1			
<i>Psectrocladius cf limbatellus</i>				2				

Table 46.

Mjöe 2. 1964

Date	1.5.	18.5.	7.6.	20.6.	5.7.	23.7.	5.8.	23.8.	11.9.	8.10.
Temp. +C°	15	17	17	23	25	21	22	17	15	15
<i>Gerris lacustris</i> macropterus					1	2	2			
<i>Ephydra</i> sp. pupae					1	1				
Chironomidae, larvae	2	3	2	2	2	2	2	2	1	
Chironomidae (hatching)		2								
<i>Hydrophorus praecox</i>				2	2		1			
<i>Coenosia pumila</i>					1		1			
<i>Schoenomyza litorella</i>					1	1				
<i>Ephydra alandica</i>			1	2	2	1	2			

Table 47.

Mjöö 2. 1965

Date	15.5.	17.6.	1.7.	15.7.	21.7.	6.8.	24.8.	17.9.
Temp. +C°	17	19	21	22	23	18	15	15
Gerris lacustris, macropterus				2	2	1		
Ephydra sp. pupae				1	1			
Chironomidae, larvae	2	3	3	2	2	2	2	1
Hydrophorus praecox			1	2	2	2		
Syntormon rufipes			2		1			
Coenosia pumila			1	1				
Ephydra alandica		2	2		1	1		

Table 48.

Mjöö 2. 1966.

Date	15.5.	18.6.	28.6.	10.7.	27.7.	10.8.	27.8.	16.9.
Temp. +C°	17	20	23	23	23	21	17	15
Ephydra sp. pupae				2	2			
Chironomidae, larvae	2	3	4	2	2	2	2	2
Hydrophorus praecox		1		2	2			
Syntormon rufipes				2				
Coenosia pumila			1	1				
Schoenomyza litorella				1	1			
Ephydra alandica		2	2	1	2	1		

Table 49.

Sjöö 1A. 1964.

Date	19.4.	19.5.	20.6.	1.7.	12.7.	18.7.	15.8.	5.9.	1.11.
Temp. +C°	7	9	12	17	14	9	12	8	8
Ephydra sp. pupae						1			
Ephydra alandica		1	1	1	2	2			

The low temperatures at several of the dates mentioned above are caused by cold sea-water pouring into the rock-pool.

Table 50.

Sjöö 1A. 1965.

Date	15.4.	8.5.	25.5.	19.6.	1.7.	10.7.	1.8.	3.11.
Temp. +C°	6	7	8	11	12	9	11	7
Ephydra sp. pupae						2		
Heterochila buccata					1	1		
Ephydra alandica			2		2	1	1	

Table 51.

Sjöö 1A. 1966.

Date	16.4.	5.5.	20.5.	16.6.	3.7.	10.7.	5.8.	25.10.
Temp. +C°	5	6	6	14	17	18	15	6
Callicorixa producta							1	
Ephydra alandica				1	2		1	
Hydrophorus praecox				1		1		

Table 52.

Sjöö 1B. 1964.

Date	19.4.	19.5.	20.6.	1.7.	12.7.	18.7.	15.8.	15.9.	1.11.
Temp. +C ⁰	10	18	21	17	17	22	18	18	10
Ephydra sp. pupae					1	1			
Chironomidae larvae			1	2	1	1			
Ephydra alandica	1	1	1	3	3	1	1		
Scatella stagnalis				1	1				
Chiloxanthus pilosus				1					

Table 53.

Sjöö 1B. 1965.

Date	15.4.	8.5.	25.5.	19.6.	1.7.	10.7.	1.8.	3.11.
Temp. +C ⁰	11	16	18	19	19	21	20	9
Ephydra sp. pupae					1	2	2	
Chironomidae larvae		1	1	1	1	1	1	
Ehydra alandica			1	2	2	2	2	
Scatella stagnalis			2		2			
Scatella paludum				2				
Hydrophorus praecox				1	1			

Table 54.

Sjöö 1B. 1966.

Date	16.4.	5.5.	20.5.	16.6.	3.7.	10.7.	5.8.	25.10.
Temp. +C°	10	13	17	22	23	23	21	10
Ephydra sp. pupae					2	2	1	
Chironomidae larvae		1	1	2	1	1	1	
Ephydra alandica				2	3			
E. riparia				1	1			
Scatella stagnalis		2	1					
Hydrophorus praecox						1		

Table 55.

Sjöö 1C. 1964.

Date	19.4.	19.5.	20.6.	1.7.	12.7.	18.7.	15.8.	1.11.
Temp. +C°	10	18	20	17	17	21	18	10
Ephydra alandica		1	1	1	1	2	1	
Scatella paludum					1	1		

Table 56.

Sjöö 1C. 1965.

Date	15.4.	8.5.	25.5.	19.6.	1.7.	10.7.	1.8.	3.11.
Temp. +C°	11	17	18	19	19	22	20	9
Ephydra alandica		1		1	2	2	1	
Heterochila buccata				1	1			

Table 57.

Sjöö 10. 1966.

Date	16.4.	5.5.	20.5.	16.6.	3.7.	10.7.	5.8.	25.10.
Temp. +C ^o	10	13	17	22	23	23	21	10
<i>Callicorixa producta</i>				1				
<i>Ephydra alandica</i>			1	1		1		
<i>Scatella paludum</i>				2				

Table 58.

Tärnö 1A. 1964.

Date	19.4.	19.5.	22.6.	7.7.	15.7.	2.8.	19.8.	5.9.	1.11.
Temp. +C ^o	11	18	22	16	20	22	19	17	9
<i>Gerris odontogaster</i> (macropterus)							1		
<i>Ephydra</i> sp. pupae					2	1			
<i>Ephydra riparia</i>			2	1	1	2	1	1	
<i>Hilaria monedula</i>		1	2		1				

Table 59.

Tärnö 1A. 1965.

Date	23.4.	15.5.	20.6.	15.7.	22.7.	2.8.	15.8.	1.9.	15.9.	25.10.
Temp. +C ^o	12	17	17	22	21	22	19	17	15	10
<i>Gerris odontogaster</i> (macropterus)						1	1			
<i>Ephydra</i> sp. pupae				3	3	1				
<i>Ephydra riparia</i>			1	2	2		2			

Table 60.

Tärnö 1A. 1966.

Date	20.4.	15.5.	18.6.	10.7.	25.7.	5.8.	13.8.	3.9.	17.9.	3.11.
Temp. +C ^o	13	16	18	18	21	21	20	17	16	7
Callicorixa producta		1								
Gerris odontogaster (macropterus)						1				
Ephydra sp. pupae				2	2					

Table 61.

Tärnö 1B. 1964.

Date	19.4.	19.5.	22.6.	7.7.	15.7.	2.8.	19.8.	5.9.	1.11.
Temp. +C ^o	11	18	22	16	20	22	19	17	9
Gerris odontogaster (macropterus)							1		
Ephydra sp. pupae						2	1		
Chironomidae larvae	1	1	1	2	1	1	1		
Ephydra riparia			1		2	2	1	1	
Hilara monedula			2	1					

Table 62.

Tärnö 1B. 1965.

Date	23.4.	15.5.	20.6.	15.7.	22.7.	2.8.	15.8.	1.9.	15.9.	25.10.
Temp. +C ^o	12	17	17	22	21	22	19	17	15	10
Ephydra sp. pupae				1	1					
Chironomidae larvae		1	2	1						
Ephydra riparia			1	1	1		1			
Hilara monedula						1				

Table 63.

Tärnö 1B. 1966.

Date	20.4.	15.5.	18.6.	10.7.	25.7.	5.8.	13.8.	3.9.	17.9.	3.11.
Temp. +C ^o	13	16	18	18	21	21	20	17	16	7
Gerris odontogaster (macropterus)						1	1			
Ephydra sp. pupae				2	1					
Ephydra riparia				1	1					

Table 64.

Bockö 1. 1964.

Date	20.5.	10.6.	27.6.	5.7.	15.7.	3.8.	15.8.	5.9.
Temp. +C ^o	9	11	11	15	16	14	12	8
Ephydra sp. pupae						1	1	
Chironomidae larvae			1	1				
Ephydra alandica	1		1	2	2	1	1	

Table 65.

Bockö 1. 1965.

Date	15.5.	17.6.	1.7.	15.7.	21.7.	5.8.	25.8.	17.9.
Temp. +C ^o	8	12	15	14	16	13	9	8
Callicorixa producta						1		
Ephydra sp. pupae					1			
Ephydra alandica		2	1	2		1		

Table 66.

Bockö 1. 1966.

Date	20.4.	15.5.	18.6.	27.6.	10.7.	25.7.	8.8.	28.8.	17.9.
Temp. +C ^o	7	8	16	17	18	18	16	12	9
Ephydra sp. pupae					2	1			
Ephydra alandica		2	2	1	2		1		
Hilara monedula				1					

Table 67.

Harö 1. 1964.

Date	20.5.	10.6.	25.6.	9.7.	15.7.	1.8.	14.8.	5.9.	11.10.
Temp. +C°	19	20	23	27	24	13	14	16	16
<i>Callicorixa producta</i>							1		
<i>Ephydra</i> sp. pupae				2	1	2	1		
Chironomidae larvae	1	1	2	1					
<i>Ephydra alandica</i>	1	2	3	3	2	2	1	2	2

Table 68.

Harö 1. 1965.

Date	15.5.	17.6.	1.7.	15.7.	21.7.	6.8.	24.8.	17.9.
Temp. +C°	17	19	21	22	22	18	15	15
<i>Ephydra</i> sp. pupae				2	2			
Chironomidae larvae		1	1	1				
<i>Ephydra alandica</i>	2	2	1		2		1	2
<i>Heterochila buccata</i>			1					

Table 69.

Harö 1. 1966.

Date	15.5.	18.6.	28.6.	10.7.	27.7.	10.8.	27.8.	16.9.
Temp. +C ^o	17	20	23	23	22	21	17	15
Ephydra sp.pupae				1	1			
Chironomidae larvae	1	1	1	1				
Ephydra alandica	1	1	2		2	2	1	

Table 70.

Mjöö 1. 1964.

Date	1.5.	18.5.	7.6.	20.6.	5.7.	23.7.	5.8.	23.8.	11.9.	8.10.
Temp. +C ^o	15	18	17	23	25	21	22.5	17	15	15
Ephydra sp. pupae					2	2				
Chironomidae larvae	1	2	2	1	1	1	1	1	1	1
Chironomidae hatching		2	1							
Hydrophorus praecox				1	1					
Ephydra alandica			1	2	2	1	1	1		

Table 71.

Mjöö 1. 1965.

Date	15.5.	17.6.	1.7.	15.7.	21.7.	6.8.	24.8.	17.9.
Temp. +C ^o	17	20	22	22	23	19	16	15
Ephydra sp. pupae			2	3	2			
Chironomidae larvae	2	2	1	1	1	1	1	
Heterochila buccata			1		1			
Hydrophorus praecox		1		2				
Ephydra alandica		2	3	3	2	2		

Table 72.

Mjöö 1. 1966.

Date	15.5.	18.6.	28.6.	10.7.	27.7.	10.8.	27.8.	16.9.
Temp. +C ^o	17	21	23	23	23	21	17	15
Ephydra sp. pupae				3	4	1		
Chironomidae larvae	1	2	1	1	1	1	1	
Heterochila buccata				1				
Ephydra alandica		2	2	3	3	1		

